THE RESTORATION OF VALVED HIGH FREQUENCY COMMUNICATIONS RECEIVERS

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PREFACE TO SECOND EDITION

Several years have passed since this book was first published on Simon Buxton's VK2BV website. The writer now realises he is lucky to have started in this hobby many years ago, long before the prices of old radios started to rise appreciably. But even in 2011, there is no shortage of collectable and restorable old radios newly emerging from old storerooms and garages all over the UK, some of them having been in there for decades. There seem to be many young people keen to learn the skill of working on this equipment. That is the good news for our hobby. Sadly, those who performed the original design and operational work are now elderly, and many are no longer able to teach the knowledge. Hopefully this book will help to plug the gap. Valves remain widely available but the emerging threat is forgeries, and some prices are rising out of control. This topic is discussed for the first time. The writer extends his most sincere thanks to VK2BV for publishing this book in its second edition.

Table of Contents

These can be found on the web at http://www.vk2bv.org/gallery/2-parry with numbering corresponding with that below. Note that pictures marked N are not yet available. The same reference numbers, including those with letter N below, appear at the relevant points in the text.

[Pic001] Marconi CR100 mounted in a home constructed handling frame which protects the chassis in any position while it is receiving attention on the bench.

[Pic002] PSEI Trophy-8 has paxolin valve sockets which cause earthing problems for the solder tags, as shown here on the RHS mounting screw sandwiched between the paxolin and the chassis - look carefully!

[Pic003] GEC BRT400K showing a re-soldered chassis seam. Sprung joints are very common indeed on this model.

[Pic004]N Drake R4C plastic gears, which feel very rough. The later metal gears work better, but are rare.

[Pic005] Eddystone EA12 uses nylon dialdrive pulleys which swell over time due to water absorption. The result is excessive pointer travel from end to end.

[Pic006] Marconi CR100 centrally captivated band change cord, which proved extremely difficult to replace. Look carefully to see how the cord enters the little metal drum in two places. It's very difficult indeed to assemble it correctly.

[Pic007] GEC BRT400K steel dialdrive wire runs in greased brass guides. Early variants (without front panel handles or dial lock) used pulleys. Dial lamps have been removed for clarity.

[Pic008] British Army R209 Mk2 pressure testing set-up, showing the desiccator which has to be temporarily replaced by a purging bung for this operation. When all is well, the manometer shows unchanging pressure after initial pumping.

[Pic009]N Hammarlund SP600JX-6 idler wheel & tensioner spring, a troublesome arrangement when the spring gets weak or if any oil gets onto the friction surfaces.

[Pic010] National NC100XA dialdrive endstop plate shown standing vertically with one bevelled corner visible. This is a very poor design which required careful filing to operate correctly.

[Pic011]N Collins R-390A Oldham coupler & tension spring, a very effective design which expedites dismantling and reduces the chance of muddling on reassembly.

[Pic012] KW202 tuning capacitor, showing its non-standard glued plastic cover which considerably reduces VFO drift. Also shown is the Kokusai 455kHz SSB mechanical filter.

[Pic013] Murphy B40D tuning gang, with its fragile ceramic shaft which snaps if the radio has been dropped. This is a scrap set, hence the dead leaf on the LO valve socket!

[Pic014]N Russian Army P-123M has a ground glass screen for optical projection of its frequency display, a very Germanic design detail.

[Pic015] Racal RA17L filmstrip scale, a thoroughly well engineered solution. Dial bulb removed for clarity. The big disc is the MHz display dial. Its outer knurling bites the dial lock brakeshoe rubber when required.

[Pic016]N RCA AR8516L metalwork, now with steel structural fastenings to replace the weak brass originals.

[Pic017] GEC BRT400K SRBP tag board, now patched with an FR4 plate as is commonly necessary on this model.

[Pic018] Murphy B40D needs air to enter this very heavy radio from underneath. The tuning chain can be seen wound round its small drive sprocket which can be seen through the big hole in the casting.

[Pic019] Marconi Atalanta panel damage caused by botched knob removal, a common problem due to poor knob design.

[Pic020] Kwikfyl crayons, a tin of Humbrol enamel and the pointed application tool used by the writer.

[Pic021]N Drake R4C showing new NB4 noise blanker PCB, built because of the unavailability of original parts from this manufacturer.

[Pic022] Philips EFM1, a rare magic eye with integral AGC-controlled AF pentode on the problematic CT8 base. Also shown is an RCA 7360 beam-deflection valve.

[Pic023] Eddystone S770R/1 special RF valve socket with two turned pins instead of the standard stamped items.

[Pic024]N Hallicrafters S36 RF unit with its special acorn valves, an elegant early solution for VHF operation.

[Pic025]N McMurdo DST100 damaged cast cabinet handle which presents a lifting hazard, as now clearly labelled.

[Pic026]N RCA AR8516L showing some original UNC rivnuts, and metric replacement fastenings retained by Araldite.

[Pic027] British Army R209 Mk2 desiccator cartridge, with its rubber O-ring seal. Shown with home made pressure testing adaptor which includes the Schrader valve used to prove sealing.

[Pic028]N Mullard MAS274 showing a typical Philips Bowden cable, used here to drive the tuning gang. Why Philips did things this way is a bit of a mystery.

[Pic029] Collins R-390A bellows coupler employed to turn the BFO shaft whilst accommodating squeeze & stretch. At the bottom of this picture are two Sprague Black Tubular (BT) capacitors which must be replaced. To the left of them is a Vitamin-Q which a reliable type.

[Pic030] Hand tools most commonly used by the writer in his own workshop for radio restoration work. Yes, the roll of kitchen towel is there deliberately! The chassis to the left is a Marconi CR100/B28.

[Pic031] Marconi CR100 is a very properly engineered radio which has an ill-deserved reputation for drift and unreliability. The little subchassis standing up to the left of the gang is the noise limiter, with its toggleswitch.

[Pic032] Marconi CR100 showing ceramic pillars used to replace original stud-ended tubular capacitors. A modern polyester capacitor is strapped across the pillar from top to bottom, to replicate the original earthing arrangement.

[Pic033] Marconi CR100 band change shaft is split to allow the flexibility necessary on mid-production chasses such as this one. The misalignment is due to a design or manufacturing error which was fixed in late production models.

[Pic034] Marconi CR100 replacement mode switch is a very tight fit. Note use of wire identifier tags and ink legends on the switch wafer.

[Pic035] Marconi CR100 underside view showing absence of BFO cover, discarded at some time due to overcrowding. This chassis has even gaps everywhere: a good layout.

[Pic036] Eddystone EA12 showing two of these receivers, both unrestored but in basically good condition.

[Pic037]N National HRO-MX stator contact for the coilpack now has a screw & nut replacing a failed original rivet.

[Pic038] National NC100XA interior view of the catacomb casting. Centre top biscuit removed, to show stator contacts visible through the shaped hole. Rack & pinion drive mechanism to the right of the carriage. Notice the mighty guide bar to the left of the carriage!

[Pic039] Eddystone S358X has a very unreliable single pole mains switch which can fail to break. B40s use the same family of switch: a potential fire & safety hazard.

[Pic040]N McMurdo DST100 slotted-dolly BFO toggle switch fabricated from various spare pieceparts.

[Pic041] GEC BRT400 Mk1 IFT carries 240VDC between the RHS (secondary) bobbin and its overwinding, shown here. There is no gap and no meaningful insulation so flashovers are common, especially in damp conditions. Notice the Philips beehive trimmer, a type prone to short circuits. Later BRT400D IFTs had mica fixed capacitors but kept the beehives.

[Pic042]N Hallicrafters SX28 has a small bead of Araldite to secure this voltage switch in the 230V position, to ensure safety on UK mains.

[Pic043] Eddystone EA12 has an unreliable mains connector, relying on a single-sided blade to connect the earth.

[Pic044] GEC BRT400D with typical decomposing bitumen-impregnated Iron HT components, a very common cosmetic problem on GEC and Philips sets - and also on the RCA AR8516L.

[Pic045] Marconi CR100 grid caps rewired in 16/0.2mm PVC for the LO (left), and RG316/U PTFE coax cable for the mixer (right). Also shows Hellermann insulating sleeves.

[Pic046] EKCO R1155A original screened cable fitted with a new 16/0.2mm PVC inner, to preserve appearances. The new PVC insulation can be seen next to the grid cap.

[Pic047] Philips 6H8MG, a rare double-diode pentode used in the unusual AME 7G1680BA receiver. The nearest sensible equivalent is the 6B8 from the USA.

[Pic048] This PSEI Trophy-8 uses Meccano chain drive. One example has been seen with a rubber belt instead. Probably the writer's set was modified at some time.

[Pic049] PSEI Trophy-8 chassis design gives plenty of room to its RF box. Note the retrofit HT fuse mounted by the output transformer, and the new mains cable, fitted by the writer. These modifications are intended to promote safety.

[Pic050] PSEI Trophy-8 front panel shows the barometer glass. Note the circular legend rings missing from two switches.

[Pic051] PSEI Trophy-8 general view, showing the cabinet and unusually tidy chassis topside layout. Notice the huge gold-metallized 6TH8G triode-hexode mixer.

[Pic052]N Hammarlund SP600JX-6 first LO valve uses this special can, which screws down onto the RF unit. The best choice of LO valve for this chassis is the 6135.

[Pic053] GE compactron type 6AS11 contains two signal triodes and an output beam tetrode, shown alongside a 5749/6BA6W pentode.

[Pic054] Acorn glass triode which seats into this type of special ceramic socket for the Hallicrafters S36 receiver. Also shown is a later, more advanced 6CW4 nuvistor triode which was in volume production for USA TVs for a couple of years. These were very high technology devices employing ceramic/metal seals.

[Pic055] Eddystone EA12 uses blobby solder joints, as with this resistor on the rear panel. These joints can be found open circuit sometimes.

[Pic056] Eddystone EA12 uses many cheap and nasty components such as these troublesome grey Dubilier resistors. Notice again, the horrible original solder joints.

[Pic057] Lozenge mica capacitors often go leaky. Some American types ooze sticky froth where the leadout wires emerge from the plastic casing when a high DC voltage is applied. This is a sure indication of trouble.

[Pic058] Hunts "Mouldseal" moulded capacitors like these, are extremely inclined to crack open and go leaky or open circuit. The writer's policy is to replace them on sight!

[Pic059] Cornell-Dubilier bathtub block containing 2 x 100nF/400V oil filled paper capacitors.

[Pic060] EAC R-390A IF unit has Sprague BT capacitors with colour-coded rings. They are very unreliable, and a fire hazard.

[Pic061] Eddystone EA12 uses cheap red, yellow & black Plessey electrolytics. These often dry out and lose value.

[Pic062] Collins mechanical filters, all 455kHz: 12kHz for 75A-4, 2.1kHz for early KWM-2, 500Hz for 75A-3 and a current high performance 12-pole SSB filter.

[Pic063] R-390A mechanical filters from all three manufacturers who made them: Collins, Dittmore-Freimuth and Whitewater Electronics. Some ceramic filters from Clevite were also fitted - not shown here. Beware Collins round-emblem filters which rattle due to rotten foam inside.

[Pic064]N Mallory R-390A electrolytic capacitor with new innards. All done using a lathe, two new 105°C-rated capacitors, and some Kapton tape. Then potted in Araldite, keeping the blow-out plugs clear.

[Pic065]N Hallicrafters SX28 brass meter casing had suffered severe “season cracking”, repaired using masking tape and Araldite. This strange fault seems very common.

[Pic066] British Army R209 Mk2 is a very pleasant small HF receiver which works very well indeed. Design quality was excellent. Production was by MEL o/b/o Philips.

[Pic067] Largely Marconi workshop instrumentation, the most useful being the TF1041C VTVM in the foreground and the two TF144H signal generators. The oscilloscope is a Cossor CDU150. Note the prominent emergency STOP switch.

[Pic068] Megger insulation tester type 70158, used on its 500V range in the UK where the nominal mains voltage is 230VAC. Great care is needed when in use!

[Pic069]N Collins R-390A green & red screw heads show fastenings that are safe & unsafe to remove respectively. Simple, sensible and clever.

[Pic070]N Motorola R-390 green gearwheel gets put into mesh to maintain gear train integrity when RF unit is removed. Shown here in its storage position.

[Pic071]N Collins R-390A VFO interior, showing the leadscrew, corrector stack, follower nut and ferrite core.

[Pic072]N Collins 75A-4 PBT mechanism uses a bronze belt to rotate the PTO and the BFO simultaneously. Simple and reliable.

[Pic073]N Collins R-390A mains input filter, useful both for keeping LO off the local mains and for stopping power line interference from getting into the radio.

[Pic074] The writer, Chris Parry photographed in March 2002.

[Pic075] National NC100XA is a handsome radio, but the great height of the tuning knob makes it tiring to operate.

[Pic076] National NC100XA on the LF band of its coverage. Most of the radio electronic circuits are openly accessible. This side of the chassis is to the original design.

[Pic077] National NC100XA on the HF band of its coverage. This switch position reveals the PSU & AF sections, all non-original due to wiring problems and missing Iron components.

[Pic078] National NC100XA topside view, showing a generally tidy layout using the old style HRO crystal filter. The PSU and audio strip is totally non-original, necessary because of rotten wiring and missing Iron components.

[Pic079] Marconi CR100 operated well under battle conditions as its knobs are large and widely spaced. The RIS connector has been replaced by an S-meter, as is common.

[Pic080] KW202 & Heathkit SB-300 competed for the radio amateur’s money, and both were competent designs.

[Pic081] Heathkit SB-300 topside, extremely neat and tidy. This example has three crystal filters, and a full set of six range conversion crystals. There is one compactron. The VFO came from TRW, and is very competent indeed.

[Pic082] Heathkit SB-300 underside, which is a bit too crowded at the lower left around the power supply.

[Pic083] KW202 topside, showing lots of wires. The vertical PCB in the foreground is the calibrator, and at rear left is the solid state notch & Q-multiplier board. Notice the writer's black plastic cover over the VFO capacitor, to reduce drift. Also notice the yellow Kapton tape covering a hole on top of the VFO box. This is directly below the lid finger hole. It stops unwanted rubbish getting into the VFO.

[Pic084] KW202 underside. The two big series resistors feeding the VFO are exactly as fitted originally. Notice how the PCB groundplane is broken up by lots of heater tracking. This causes excessive hum in the audio.

[Pic085] EKCO R1155A with the late dialdrive is a truly excellent receiver, and very light in weight. A previous owner has removed the DF facilities. This example has been much hacked-about over the years, and is typical of most survivors of this model.

` [Pic086] EKCO R1155A RF interference trap canister supported only by a small bent Aluminium bracket. It nevertheless proved strong enough to withstand the shock, bump and vibration in a Lancaster bomber aircraft.

[Pic087] EKCO R1155A has a clever coilbox which allows access from 2 orthogonal faces, to improve serviceability.

[Pic088] EKCO R1155A topside is very crowded even though all the DF hardware has been removed from this example.

[Pic089] EKCO R1155A underside, showing plastic wire-ended capacitors in place of the stud-ended originals. The new output transformer can be seen clearly.

[Pic090] Eddystone S770R/1 is a handsome set, very heavy for its size. It was made for many years and sold well because there was little competition.

[Pic091] Eddystone EA12 variable selectivity. The ¼" shaft carries three cams & levers which change the position of one winding inside each 100kHz IFT. The red Hunts dipped capacitors shown here are usually OK, but beware these grey Dubilier resistors.

[Pic092] Eddystone S770R/1 is extremely hard to work on, as access is very poor indeed. This one had to be dismantled for repairs to the IF and AF modules.

[Pic093] Eddystone S770R/1 has some heroic engineering underneath! The antenna trimmer shaft leaves the RF unit at a rakish angle to reach the front panel via two UJs.

[Pic094] Eddystone S770R/1 showing a lot of valves crammed into the space available, a neatly executed design. Inadequate ventilation means this set is a hot runner.

[Pic095] This Eddystone S770R/1 audio unit is actually taken from an S770U. Many new bits are fitted, as a lot of the original components were cooked.

` [Pic096] Eddystone S770R/1 RF strip originally fitted with three EF95s, now has a 6AJ5 variable-μ RF amplifier. Selection is needed to choose the right sample because not all 6AJ5s have a suitable transfer characteristic. TungSol examples work fine here.

[Pic097] Eddystone EA12 uses logarithmic compensation of scale linearity. Various covers go over this assembly. Notice the top quality Philips beehive trimmers, which have proper machined leadscrews for a change. The writer wonders why GEC did not use these in the BRT400.

[Pic098] Eddystone EA12 underside has a very neat layout, especially considering all the many user features.

[Pic099] Eddystone EA12 chassis topside, with an FR4 plate temporarily covering the loudspeaker to protect it from damage during servicing.

[Pic100] Eddystone EA12 uses fragile rear panel terminals which have no physical protection. Typical Eddystone, sadly.

[Pic101] Eddystone EA12 uses small coils and SRBP switch wafers which were no doubt cheap, but they reduce the unloaded Q significantly.

[Pic102] GEC BRT400K has a new loom fitted along the power supply sidewall, shown at the bottom of this photo. The original loom was fried due to shorts somewhere in the bulb wiring, which is a common fault.

[Pic103] GEC BRT400K is a handsome radio but heavy, and the chassis is very inclined to crack and develop other structural failures. Early BRT400s lacked front panel handles and calibrator but went up to 33MHz, and not all late sets had the calibrator.

[Pic104] GEC BRT400K has deep RF compartments which are hard to work inside. Most chassis seams are riveted & soldered, but the RF bulkheads are riveted only.

[Pic105] GEC BRT400K chassis topside view showing a new mains transformer cover. This set started as a BRT402K, and was later given the correct table cabinet to convert it into a BRT400K. Note Kapton tape over the IFT holes, to keep dirt out. Beehive trimmers make this a very wise precaution. Notice the adaptor plates used to fit B7G valves into chassis holes originally used for B8G types.

` [Pic106]N GEC BRT400D chassis topside showing two KT81s, which were changed to inferior but much cheaper EL84s on later model variants.

[Pic107] GEC BRT400K chassis underside view showing the set as easier to work on than is actually the case. Notice the heavy metal cover over the LO compartment, and also notice the BFO cover at the top right. Equally notice the lack of any proper covers over the aerial, RF amplifier and mixer sections of the bandchange compartment.

[Pic108] GEC BRT400K audio/AGC section is almost the ultimate in valve radio design. In the opinion of this writer only the earlier BRT400D/E was better, care of a posh KT81 beam tetrode output valve rather than a downmarket EL84.

[Pic109] Telefunken E127KW/4 panel has a large half-moon dial. The knob pushes & pulls to give two speeds.

[Pic110] Telefunken E127KW/4 chassis topside view. Steel perimeter frame is an integral part of this radio.

[Pic111] Telefunken E127KW/4 has this unusual tapped power resistor.

[Pic112] Telefunken E127KW/4 RF unit is quite compact. Extremely good quality components throughout.

[Pic113] Telefunken E127KW/4 IF unit uses surprisingly simple distributed LC & crystal filtering.

[Pic114] Telefunken E127KW/4 chassis underside view is conventional, with large pressed metal screening covers.

[Pic115] Telefunken E127KW/4 dial plate is in cast Aluminium, lit by four bulbs to give unusually bright illumination.

[Pic116] Telefunken E127KW/4 dial is a beautiful piece of work, allowing surprisingly accurate and repeatable frequency readout. Notice the lenticular magnifier.

[Pic117] British Army R209 Mk2 chassis topside view, with two modules removed to highlight the plug-in construction.

[Pic118] British Army R209 Mk2 module, showing IFT and battery valve.

[Pic119] British Army R209 Mk2 chassis underside shows easy accessibility. The heavily screened box on the left contains the vibrator. The RF box is on the right.

[Pic120] Murphy B40D is a strange-looking but handsome set which is also unusual in its engineering. The massive cast front panel is not as strong as it looks: beware!

[Pic121] Murphy B40D turret is magnificent. It can only be faulted for the small size of the coils in each biscuit. Individual sections are fully screened. Accessibility shows all others how it should be done.

[Pic122] Murphy AP100335 is an RN LF + HF receiver designated type 618, designed for smaller vessels. It is very different from the B40, but still unconventional. As yet unrestored. Pye made an inferior direct equivalent to this receiver, selling as Rees-Mace.

[Pic123] Murphy B40D with its PSU/AF tray slid back slightly, to highlight the cast Aluminium construction.

[Pic124] Murphy B40D IF side, also showing the PSU and audio valves. The modules separate quickly and easily.

[Pic125] Racal RA17L is an ex-RN radio with especially good ergonomics. This is one design that works much better than its on-paper performance would indicate.

[Pic126] Racal RA117 + RA218 ISB adaptor, fitted with spurious front panel labels. Complete and fully functional. More complex but cleverer than the RA17L, and capable of operating with an early synthesizer called a “Racalator”.

[Pic127] Racal RA17L bottom covers must be fitted tightly and with clean & bright fingerstock to reduce spurii.

[Pic128] Racal RA17L topside. The chassis is deeper than on other commonly seen radios. All very neat, but module removal is certainly not straightforward.

[Pic129] Racal RA17L underside view, showing cast compartments. Critical filters live under the L-shaped covers left in position here. The box at the bottom right contains the antenna attenuator switch.

[Pic130] Two S130Ps: LHS is a balloon-top Cossor, RHS is a GEC in shouldered glass. They have very different regulation behaviours. Not all GEC S130Ps glow orange. Notice the wire mesh priming electrode inside the LHS valve.

[Pic131] Racal RA17 original prototype, as displayed for several years in the foyer of the Racal HQ in Bracknell, UK. Note the choice of knobs.

[Pic132] Racal RA17 original prototype. The left and right are NOT two separate castings. Difficult problems of spurii led to the original single casting being band sawed into two completely separate halves. Look carefully and you will see the sawcut! This broke the path of the earth current, enabling correct performance to be achieved.

[Pic133] Racal RA17 prototype, all pretty much as would be expected apart from the 5Z4G rectifier, which must have worked too hard in this application! The famous sawcut is in evidence from left to right of the chassis, just below halfway down.

[Pic134] Racal RA17 prototype underside, showing a single screening plate with the large retrospective hacksawed cut-out to achieve correct grounding and proper routing of earth currents. Production RA17s had a more complicated screening arrangement.

[Pic135] AWA CR-6A and CR-6B radios, one with the correct table cabinet and the other with the optional multi-channel unit. Somewhat smaller and lighter then the norm, these are among the writer's favourite radios.

[Pic136] AWA CR-6B chassis topside, all very open and straightforward. This radio has the optional multi-channel unit fitted. The Cadmium plating is in good condition and the chassis looks much as it would have done when new.

[Pic137] AWA CR-6B RF unit showing the demountable construction and the use of top-class Philips beehive trimmers having proper leadscrew adjusters. Why did not more manufacturers use these components? The variable capacitor shows its ceramic shaft in this photo.

[Pic138] AWA CR-6B pre-adjusted demountable IF block filter, also showing the optional six position multi-channel module. This perfectly sound idea was next seen years later in the Pye Cambridge mobile radiotelephone.

[Pic139] AWA CR-6B chassis underside showing the proper fitted cover beneath the RF unit to stop draughts and promote frequency stability. The mighty bandchange roller chain is rather as seen in the RCA AR8516L - but the AWA implementation works better. The selectivity wafer switch at the top of this photo forms part of the IF block filter module. Notice how easy this set is to work on - very intelligent design.

[Pic140] AWA CR-6B close-up of the selectivity switch, carried on a metal bracket which also accommodates the five 100kHz IF coils. No nasty micas to drift away from the correct values! Notice how the main radio chassis is fitted with Mullard tubular polyester capacitors. These are about the only type still considered reliable some fifty years after they were made.

[Pic141] KW2000E is a very handsome transceiver. This is the final model, which tunes in 500kHz segments. It has RIT, TIT etc and good VOX facilities. It came to be known as the "E for Expensive" variant!

[Pic142] KW2000E interior, showing conventional chassis construction and at lower right, the dropper for the 150V zener HT regulator. An 0A2 neon had been fitted to earlier models. The large cylindrical can is the Kokusai mechanical filter.

[Pic143] KW2000E vertical FR4 PCB was termed the "KW Vox Box". It may perhaps have been standard fit instead of an option as on earlier models. The oversize washer on the PCB corner was fitted by the writer to protect transformer IFT5 when the chassis is being handled on the bench. The large B9A valve fitted with the spring retainer is the ECL82 for audio output.

[Pic144] KW2000E rear panel, showing the small Painton multi-way connector which carries raw mains, +1000V HT off load, and transistor supply voltages from the external PSU box. The metal shell of the mating connector is not even grounded! This is extremely dangerous equipment design.

[Pic145] KW2000E showing plastic boxes added by the writer to improve frequency stability and reduce dust ingress. Notice the yellow Kapton tape covering a hole on the top of the VFO module. This aperture is directly below the finger-hole in the cabinet top cover. A delicate Philips beehive trimmer lies directly underneath. The tape stops debris falling into the VFO, and also captivates the bulb wiring.

[Pic146] GEC BRT400D showing the desirable extractor fan modification. This model otherwise gets far too hot to be reliable in old age. This version predates the BRT400K. Three B8G valves, an octal and three B7Gs are shown in this photo. The unusual B7G valvecans are original to this radio.

[Pic147] British Army R209 Mk2 power unit, showing the solid-state vibrator. It works very well, but forces the radio supply polarity to be negative earth. The original WICO mechanical vibrator made no internal connection to its can, so did not cause this problem.

[Pic148] RCA AR88D chassis underside, showing excellent screening arrangements. All rotary switches have ceramic wafers like those shown here. The multisection smoothing block is being rebuilt using 3 pairs of 10µF/450V/105°C high reliability electrolytics in series, each strapped by a 220kΩ TR6 metal oxide voltage-balancing resistor. This gives 5µF per section instead of 4µF originally, with a total effective bleed resistance of 147kΩ.

1. Foreword and Acknowledgements

This book is the distillation of over 35 years work, both in a professional capacity and as an enthusiastic collector and restorer. I hope you find it interesting and useful. If you find any errors in it, or if you want to bend my ear about any of my opinions I have stated or any of the techniques I have advocated, then please feel free to contact me:

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2. Scope

This book covers the restoration of valve HF receivers developed for sale into military, amateur or industrial markets. It does not contain rebuild or repair information relating to cabinets, front panels or antennas. Domestic broadcast receivers are of little interest to this writer and are not covered as a specific topic, though much of the book would be found useful if working on such equipment. Some of the equipments discussed in this book are HF transceivers. In these cases, the transmitter functionality and performance aspects are disregarded.

3. Abbreviations

ABS	Acrylonitrile Butadiene Styrene, a popular plastic moulding material
AGC	Automatic Gain Control
AFC	Automatic Frequency Control
AFV	Armored Fighting Vehicle
AM	Amplitude Modulation
AME	Ateliers des Montages Electriques
ANL	Automatic Noise Limiter
AWA	Amalgamated Wireless (Australasia) Ltd
AWV	Amalgamated Wireless Valve Co Pty Ltd
BA	British Association thread
BABT	British Approvals Board for Telecommunications
BFO	Beat Frequency Oscillator
BK	Barkhausen-Kurz
BT	Black Tubular, a family of unreliable Sprague paper capacitors
BVA	British Valve Association
CAA	(UK) Civil Aviation Authority
CAD	Computer Aided Design
CENELEC	European Committee for Electro-technical Standardization
CNR	Combat Net Radio
CRT	Cathode Ray Tube
CW	Continuous Wave
DF	Direction Finding
DMM	Digital Multi-Meter
DPDT	Double-Pole Double Throw
DSP	Digital Signal Processing
DWS	(UK) Diplomatic Wireless Service
EAC	Electronic Assistance Corporation
EKCO	E K Cole Ltd
EMF	Electro-Motive Force
ENR	Equivalent Noise Resistance
ETSI	European Telecommunications Standards Institute
FM	Frequency Modulation
FSD	Full Scale Deflection

GCHQ	Government Communications Headquarters in Cheltenham, UK
GDO	Grid-Dip Oscillator
GEC	General Electric Company Ltd (≠ General Electric USA)
GKN	Guest, Keen & Nettlefold Ltd
GPO	(UK) General Post Office
GSM	Global System for Mobile telecommunications
HF	High Frequency
HMP	High Melting Point
HT	High Tension
IF	Intermediate Frequency
IFT	Intermediate Frequency Transformer
IPA	iso-Propyl Alcohol
ISB	Independent Sideband
ITU-R	International Telecommunications Union - Radio
JAN	Joint Army/Navy (USA)
LHS	Left-Hand Side
LMP	Low Melting Point
LO	Local Oscillator
MARS	Military Affiliate Radio System
MDF	Medium Density Fibreboard
MEL	Mullard Equipment Limited
MFP	Moisture and Fungus Proofing
MOD	(UK) Ministry Of Defence
MSK	Minimum-Shift Keying (mod index = 0.5)
MTB	Motor Torpedo Boat
MUF	Maximum Usable Frequency, especially high in the summer daylight hours during high sunspot activity.
NOS	New, but Old Stock
NTC	Negative Temperature Coefficient
o/b/o	On Behalf Of
p-p	Peak-to-Peak
PAT	Portable Appliance Tester
PBT	PassBand Tuning
PCB	Printed Circuit Board or Poly Chloro-Benzene (hazardous material) (context sensitive)
PD	Potential Difference
PIV	Peak Inverse Voltage
PMR	Private Mobile Radio
PRC	People's Republic of China (the mainland)
PSEI	Peto Scott Electrical Instruments
PSU	Power Supply Unit
PTFE	Poly Tetra-Fluoro Ethylene, a low-loss plastic capable of high temperature operation
PTO	Permeability Tuned Oscillator
PVC	Poly Vinyl Chloride
QPP	Quiescent Push-Pull
R&S	Rohde & Schwarz
RAF	(UK) Royal Air Force
RC	Resistance-Capacitance
RCA	Radio Corporation of America
RCL	Resistance, Capacitance, Inductance
RF	Radio Frequency
RFC	Radio Frequency Choke
RHS	Right-Hand Side
RIS	Radio Interference Suppression
RIT	Receive frequency Independent of Transmit frequency
RMA	(USA) Radio Manufacturers' Association
RME	Radio Manufacturing Engineers

RMS	Root of the Mean of Squares
RN	(UK) Royal Navy
ROC	Republic of China (Formosa, Taiwan)
Rx	Receiver
SAE	(USA) Society of Automobile Engineers
SMPU	Switch-Mode Power Unit
SNR	Signal to Noise Ratio
SPST	Single-Pole Single Throw
SRBP	Synthetic Resin-Bonded Paper
SRE	Ship's Received Entertainment
SRF	Self-Resonant Frequency
SSB	Single Sideband
TCW	Tinned Copper Wire
TETRA	Trans-European Trunked Radio Architecture
TIT	Onboard Transmitter frequency Independent of external Transmitter frequency
Topband	1.8MHz to 2.0MHz
TRF	Tuned Radio Frequency
TSC	Teledyne Systems Corporation
TÜV	(Germany) Regional Boiler Testing Inspection Agency, a family of accredited test & certification bodies
Tx	Transmitter
UHF	Ultra-High Frequency
UJ	Universal Joint
UNC	Unified National Coarse thread
VFO	Variable Frequency Oscillator
VHF	Very High Frequency
VTVM	Vacuum-Tube VoltMeter
WARC	World Amateur Radio Congress
μ-metal	Magnetically soft Iron

4. Objectives

The view of this writer is that what should primarily be restored is the original electrical and mechanical performance. If possible, this should coincide with an exact physical restoration of the chassis. Where this is not possible, the changes made to the physical construction of the receiver should be kept to the absolute minimum. There is an argument that this approach may show future generations more of how the unit was restored than how it was originally built. This viewpoint is entirely accepted. However, at least it will be possible to see how the designer intended the unit to function.

It is advocated that in some cases, mains arrangements should be upgraded to reflect modern day practice. This is to ensure the continued safe operation of the product, well into the future. Again, it is accepted that this may cause some loss of originality.

5. The Restoration Process

The work should proceed in four stages, in the following order.

1. Renovation of chassis and mechanical assemblies.

2. Repairs to wound components and wiring.

3. Replacement of valves and other components.

4. Faultfinding and realignment.

This sequence is almost the reverse of what would normally be attempted in the way of repairs to an equipment of recent manufacture. This implies that major chassis components and inductors will usually be found in original condition, even on the older equipments. Valves and sundry minor components will have been replaced many years ago, perhaps two or even three times. A number of past repairs will ordinarily be found, many of which will have been botched.

This book describes the techniques which the writer uses in his own workshop. There may be alternative methodologies which would work even better for you.

The restoration materials indicated here are types available in the UK. Recognising the international readership of this book, a glossary is included in an attempt to define these materials so that locally available substitutes can be identified.

One photograph shows the tools that the writer uses most frequently in his own workshop. [Pic030] The right-angle tools at the rear left are Bristol keys, often incorrectly called Bristo keys even in official documentation. The Xcelite screwdriver set in the clear plastic case contains Allen driver bits and also Bristol, the most useful size in this range being the 99-66 tool. The combination spanners are BA rather than metric, and the nut driver is 2BA. The de-soldering braid is Chemtronics Soder (sic) Wick Rosin SD, size 5, their reference 80-5-5. This has been found far superior to the alternative types and sizes commonly available in the UK. The Weller TCP soldering tips that get the most use are heat range #7 corresponding to +700°F/+370°C, in a variety of shapes and sizes. The tool with the green handles is a wire stripper, which is used with a variety of jaw sizes. It seems worth pointing out the technique used to protect the front panel of the TF801D signal generator shown on the right of the picture. A hefty MDF plate is held in position with quick-release rubber straps. It carries four large rubber feet which sit inside the instrument front panel "picture frame", to firmly locate the plate in position.

6. Supporting Information

It is ideal to have exactly the correct technical information to hand. This may prove unexpectedly difficult to find, or even to identify. It is also highly advisable to obtain details of the various production or service modifications applicable to your unit. Before the commencement of any work, the unit should be surveyed to identify its build standard and to identify any authorised or unauthorised modifications that may have been implemented, whether correctly or incorrectly.

The error rate in original documentation tends to be far higher than would be considered acceptable nowadays. Problems and uncertainties due to this cause are best resolved by reference to a "gold standard" example of the model in question if you can find one near where you live, and if the owner is sympathetic enough to let you examine it.

The overall difficulty of restoration can sometimes be compounded by the publication of spurious magazine articles, some of which have been elevated to the status of folk lore since the 1960s when so many of them first appeared. These articles are usually more or less loosely based on original manufacturer's information. Almost the worst case possible, is when you try to restore a chassis that some previous owner has repaired well (ie almost invisibly) using a recent magazine article based on one of the earlier ones. The opportunity for error has then increased greatly compared with what was in the manufacturer's original production drawing package. And that may have been none too good in the first place!

Because each radio design had its own set of stock faults when in service, a lot of time can be saved by getting wise to these sooner rather than later. Contemporary magazine articles can be invaluable as a source of information, as can old hands who used to work on these sets prior to retirement. Sometimes the list of stock faults can be surprisingly specific. For instance, the mains transformer on the Murphy B40 is unreliable… but only on the original production variant. Some B40s mistrack… but this problem will usually be found only on those examples of the later "D" variant that somehow escaped one particular authorised service modification.

7. Chassis & Mechanics

7.1 Chassis Cleaning

Stand the chassis in a convenient position, noting that some chasses cannot safely be inverted or angled far from the vertical without severe risk of mechanical damage to IFTs etc. The Hallicrafters SX28 and Marconi CR100/B28 are two examples of this inconvenience.

If faced with this problem, make a pair of handling frames right now at the start of the job, one fitted to the left skirt of the chassis apron and one to the right. Chipboard usually works fine for this job. [Pic001] Wooden chocks or metal legs can be screwed into position, to tilt the chassis to a convenient angle for working on the bench. Tall feet screwed onto the back of the frame can prevent damage to fragile rear panel connectors. By making the chipboard side plates a little higher than the tallest component on the chassis, this technique can allow full inversion of the radio on the bench without damage. In the example shown in this photograph, additional feet are fixed to the top of the frame to do the same job without restricting the access unnecessarily.

Wherever possible, dry clean using a vacuum cleaner nozzle and paintbrush. Where essential, wet clean the radio by painting/scrubbing methylated spirit onto it using a paintbrush or toothbrush, then using a vacuum cleaner nozzle to remove liquid and suspended debris. The writer has not yet exploded the vacuum cleaner doing this, but it might just prove possible, so please be careful! To avoid blue/pink staining afterwards, and alternative solvent could be chosen.

Some restorers like to use compressed air to blow away all the dust and old cobwebs. The writer avoids this because of the risk to fragile coil leadout wires and variable capacitor vanes. If using a blowgun, the best advice is to make sure the air is clean & dry, and free of oil droplets. Go gently.

Petrol (gasoline) works brilliantly as a cleaning agent but does tend to dissolve wax coatings and remove resistor colour rings, so should be strictly reserved for the most difficult cases. It works very well indeed for removing congealed grease and is therefore particularly useful on gearboxes. Jizer or Gunk may be even more suitable, and these materials are certainly much safer to use. It is suggested that cleaning be performed with the chassis standing vertically so that the used fluid with its dissolved goo does not get a chance to run down onto the components under the apron. In particular, the RF coils and the band change switch need to be protected. This cleaning job is best done outdoors, not least to reduce any fire hazard. Do not use the vacuum cleaner drying technique here, just let the radio drip dry in the open air.

For many years, Tektronix used to specify a pre-service washing procedure for their (very reliable and long lived) 500-series oscilloscopes. This writer has used cold water to wash many radios over the years, and never yet had any problems. An alternative approach used with success by some other restorers, is to use household detergent mixed with water. Try to prevent any ingress of liquid into wound components, potentiometers, ceramic trimmer capacitors or wafer switches. Thoroughly wash out all grease, oil and congealed goo from accessible bearings, and from grounding springs fitted to rotating or sliding parts.

As a rule, the worst corrosion problems are seen on radios such as the Murphy B41 and Eddystone 770U which were often used in submarines, where the prevailing atmosphere was not only condensing, but also heavily laden with salt. By doing a thorough wash job on sets like these, at least you can be sure that all the salt has gone before you start doing any serious restoration work.

A specific caution regarding Cadmium relates to the toxicity of the white oxide that forms in time on surfaces that have been stored in damp conditions. Care is definitely required when handling Cadmium-plated parts that have developed an oxide coating.

Rusted steel chassis parts can be passivated by using Jenolite before proceeding with the repair sequence.

7.2 Earthing

WARNING: AC/DC sets must not have their chassis earthed, and not all radios fitted with mains transformers have an isolated chassis. Examples exist of radios with transformers which nevertheless have the chassis connected directly to one side of the mains. This design type is most commonly found on broadcast receivers.

Corrosion of grounding points is a common problem with steel and Aluminium chassis, and particularly so with pressed Dural. The prime objective must be to restore correct earthing, appearance being an important, but purely secondary factor. Pay special attention to loose or rusty screwed or riveted earth returns. Remake all of these at this stage as a matter of course, using brand new hardware which looks as similar as possible to the original.

Many radios were assembled with cheap paxolin valve sockets. [Pic002] All too often, the securing screws were also used as grounding points. The paxolin tends to creep with age, leading to the securing screws becoming loose. The repair technique used by this writer is to fit externally serrated washers between the solder tag and the chassis. These washers have considerable in-built springiness and the sharp teeth do a good job of providing continuity.

7.3 Chassis Resoldering

Soldered chassis seams may be cracked, so they all need to be checked carefully, especially where the seam performs a structural as well as an electrical function. Resoldering must be done fearlessly, using an electric paint stripping gun to preheat the chassis followed by rapid soldering using an extremely big, very hot iron. [Pic003] If access is impossible, sort this out first by performing localised stripdown. Use an aggressive grease flux such as Fluxite, together with 60% Tin, 40% Lead cored solder. After cooling, remove all traces of flux residue using methylated spirit and the vacuum cleaner. Then perform local rework, making repairs as necessary. Pay particular attention to the integrity of insulation on wax capacitors and wiring, if they have been at all close to the heat gun or iron.

American radios from the second world war were sometimes built using a solder containing 50% Lead, because of a temporary shortage of Tin. This stuff has a higher melting point than the usual alloy of 60% Tin, 40% Lead - therefore it is not eutectic.

Modern solders frequently contain no Lead at all, and they melt & flow very differently from “traditional” solder. The writer does not know if any issues would arise if using this stuff to repair an old radio. His best advice is to use 60% Tin /40% Lead solder if available.

7.4 Grommets

Very often rubber grommets are used to support variable capacitors, RF subchasses or anti-microphonic valve sockets. These must all be replaced at this stage with brand new items. Don't bother trying to make the originals last. They probably won't go on for very much longer, and the development of related faults can be very insidious. Tuning backlash, creeping paralysis of the dialdrive mechanism, and slowly developing crackles due to intermittent waveband connections are all phenomena that this writer has positively tracked down to failing rubber bushes at various times over the years.

7.5 Gearboxes with Metal Gears

Gearboxes need checking for bent gearwheels, incorrect split gear spring preloading, tooth wear, and bearing maladjustment. Start by verifying that the gearbox side plate securing screws are good and tight, and that the gearbox frame is firmly attached to the RF subchassis or whatever else it is bolted to in your radio.

The correct endfloat for all gearbox shafts is zero, with very slight endthrust. On the average gearbox, over-tightening any one shaft will spring the side plates apart slightly, reducing the endthrust on adjacent bearings. Any adjustment should therefore be made only a little at a time.

Check the input shaft for truth. It is permissible to bend it very slightly to get it exactly right. Be careful, because it will probably be made of hard steel which will break without warning if it is strained excessively whilst the material is cold. When the input shaft is running dead true, disconnect the input and output couplings and wind the gearbox back and forth through its entire motion. The feel should be consistent throughout. Do this with the gearbox in an entirely dry state, to avoid lubricant masking any problems that may be present.

All split gears should run true and have a full compliment of tensioning springs. B40 owners should note this particularly! The amount of tension should ideally be 1½ teeth. Check that the two halves of each sprung gearwheel are free to move with respect to each other within the limits imposed by the mesh of the gears, and that the two split faces have not become corroded together, or separated too far because of wear in the hub. With the gearbox dry but uncoupled, the spring loading should be sufficient to overcome all friction and stiction in the gear train.

Some split gears are very large in diameter, even as big as 3". With these sizes it is particularly important to check that the wheel rotates concentrically, and that the two halves are properly supported by the hub.

At the end of gearbox repairs or adjustments, relubricate all bearings very sparingly with synthetic car engine oil, and all teeth with a light household oil. An alternative lubricant to consider is spray-on chain grease.

7.6 Gearboxes with Plastic Gears

The plastic gears found on Drakes are sloppy at best, and can impart a very lumpy feel to the tuning due to wear, grit or long term under-lubrication. [Pic004]

Limited application of the special grease sold for use on the nylon gearboxes of model racing cars is a good first step. It will be best to avoid using any of the usual automotive greases.

7.7 String and Wire Dialdrives

String or wire runs are often fiddly to assemble, but do tend to be relatively trouble free. The only common irritations concern nylon pieceparts. Drive pulleys on Eddystones can swell due to moisture absorption. [Pic005] This causes pointer over-travel at the extremes of motion.

Most pointer dialdrive systems used an open fabric or nylon cord, and these rarely present insurmountable problems. If replacing a cord on a radio originally fitted with waxed string, be sure to clean the pulley grooves carefully as otherwise lumps of old wax residue may cause uneven travel of the new cord. Cord knots should be sealed with a bead of polystyrene cement. Replace rusted or stretched tension springs as necessary.

The most difficult type of repair on an open string dialdrive is where the cord is positively located in the middle of its run, often being captivated to a large pulley by a clamp or loop. [Pic006] Usually, each end of the run is individually sprung. The easiest procedure is to work from the point of captivation outwards, being careful to leave plenty of cord on each side.

Whenever the need arises to temporarily captivate a new cord whilst fitting it, use little tags of PVC adhesive tape. This stuff is particularly good at holding turns in position on the drum prior to knotting. Mark exactly where the knots need to be with a black marker pen on the cord. Use double knots every time! Special spring-pusher kits are available to make handling the tension springs easier and less hazardous.

Some radios such as the BRT400D and those of the Swiss manufacturer Paillard, used an open stranded steel wire terminated at each end by soldering, without the use of any separate tensioning spring. Modelmaking shops stock plastic-covered stranded aircraft locking wire that can be used, but it is noticeably less flexible than the original. Laystraight wire may prove more suitable. Care is needed on later models of BRT400 (suffix D and onwards) to grease the wire where it passes over the brass guides. [Pic007] Early BRT400 Mk1s and most other sensible radios used pulleys instead of guide sleeves, and hence do not suffer this problem.

Collins used an open plastic-insulated stranded steel wire from the beginning on their model range. In general there are no problems, but inside the KWM-2 PA cage it is necessary to make sure the wire ends do not touch anything, to prevent any possibility of unwanted RF currents flowing along the steel core of the wire. The ability to control this problem was purportedly the reason why the factory selected the plastic covered wire in preference to the (then) more common uninsulated stuff.

Lubricant should be kept well away from cord or nylon dial strings, because it can rot the fabric in time. One useful modern lubricant that can find an application in old radios is the type sold for lubricating printer carriage slides. It contains PTFE in colloidal suspension, and has proved excellent for lubricating radio pointer slides.

7.8 Chain Drive

This technique was used by Murphy in their B40 for the British Admiralty and in an HRO variant (a German copy?) which the writer saw 27 years ago at Aston University, and which he now wishes he had inspected rather more closely. It was also used by PSEI in at least one Trophy-8, though this may be an aftermarket modification. [Pic048]

A worn chain will always cause backlash, the only variable being the exact magnitude of the problem. Tightening the inevitable jockey wheel reduces the backlash, but introduces excessive friction due to bearing side thrust. The solution used by this writer is lots of medium grade lubricant, with the tensioner set to only just take up all the slack.

Fitting a new chain will usually stop the backlash, but in the writer’s experience, the use of a new chain running on old sprockets is a recipe for stiffness and notchiness.

7.9 Friction Drive

Some highly ingenious friction drives have been designed. The key aspect for a restoration programme is to ensure an absence of uneven wear on the friction surfaces. It is also important to make sure that the spring tensioners are functioning correctly and that the lubrication conditions are correct.

Collins S-line, Hammarlund SP600, Muirhead and Eddystone types should run perfectly dry, and all of these friction mechanisms should work perfectly. [Pic009]

The cheaper National and Jackson ball drive designs are very prone to develop slop and lumpiness. Little can be done about this except to repack the ball cage assembly with Kilopoise 0868S, and to make sure the input and output shafts are perfectly aligned. Certain Jackson ball drives are still available, but no source of National ones is known to this writer. The main dial balldrive used in the KW2000B and KW204 is Jackson type 5620, which has four helical compression springs to adjust the maximum torque capacity. The preselector tuning and peak/notch balldrives used by KW in these radios are both Jackson type 4511DAF. This type is extremely similar to that used in the Yaesu FT101 series as the main VFO drive. It uses a special pre-adjusted wavy washer as the torque transmission limiter.

Any Jackson drive found to be slipping should not be the first component to come under suspicion. More often than not, the problem is caused by excessive torque demand as a result of seized variable capacitor bearings or misaligned driveshafts. Only when these points have been checked, should the Jackson drive tension springs be nipped-up to raise its torque transmission capability.

Even the smallest trace of ordinary mineral oil can quickly ruin many types of friction drive. Do not therefore, lubricate friction drive mechanisms other than as indicated above or better still, exactly as recommended in the manufacturer's documentation.

7.10 Dialdrive Mechanics

First make sure the LF and HF endstops are correctly adjusted. This can prove extremely difficult, for some designs seem not to have been right even at the start. The National NC100XA comes instantly to mind. [Pic010] The writer had to file the endstop wedges on his example, and can see no way that it could ever have worked properly without this rather bespoke operation.

You are cautioned not to experiment too enthusiastically with the endstops even though some designs (mainly British) had very heavily engineered stops and were provided with spring release over-torque clutches for dissipating excess energy from the flywheel (GEC BRT400, Murphy B40, Atalanta etc). Over-torque clutches should be adjusted to only just pass normal operational drive without slipping. Other designs were less competent, with the result that severe damage may be caused by mishandling. The National NC100XA and HRO receivers are examples. The first does have stops, but no means of slowly unwinding the flywheel. The second has no endstops at all, relying on the torque absorption capabilities of the (admittedly beefy) gearbox and variable capacitor. The friction drive Eddystones and the Hammarlund SP600 can wear flats on the rim of their driven pieceparts if spun repeatedly against the endstops, causing lumpiness.

For most dialdrive systems, the coupling to the variable capacitor is set so that with the drive mechanism against its LF endstop, the capacitor gang is just fully closed.

In the case of bellows couplers on screwed (e.g. Collins R-390A BFO) shafts, arrange for the coupler to be at its natural length in the centre of the allowed range of rotational motion.

Set any Oldham couplers to have the specified amount of endfloat, and make sure that the anti-backlash spring is present, and properly effective against the rotational stiction of the output shaft. [Pic011]

Dialdrive lubrication needs to be very sparing, the emphasis being on using the right stuff in the right places, rather than on the quantity applied.

7.11 Gang Capacitors and Mountings

Variable capacitors need careful cleaning. A good technique is to use gentle compressed air followed by gentle brushing with a strong solvent. Note the word "gentle" used twice in that sentence! Avoid bending the plates. The correct rotor endfloat is zero, with a very slight preloaded endthrust. Rotor vanes should be central with respect to those of the stator.

Rotor grounding springs need to be correctly tensioned and lightly lubricated. They must be connected properly to the chassis, or wherever else they are supposed to be wired to.

Ceramic or fibreglass insulators need to be very clean if the Q values of the connected coils are not to drop unduly.

On most good quality receivers the tuning gang has a cover, to keep out dust and draughts. Notable exceptions include the KW202 & KW2000E, certain Eddystones such as the 940, and certain Hallicrafters' including the SX62. [Pic012] For these equipments, consideration can be given to fitting a plastic cover, ideally of polystyrene or ABS. The plastic potting boxes available from RS and Maplin may be suitable, and they are certainly cheap to buy. These things come in a range of sizes and pleasingly, they lack the corner fixings found on boxes designed to accept lids. The new plastic box will be very light in weight, so it can be held in position with Evostik or silicone rubber.

Tuning backlash is often due to perished rubber mountings on the tuning gang. In the event of this problem occurring, look carefully at the movement of the capacitor frame over the complete motion of the tuning mechanism. The movement should be zero except at the endstops, where visible distortion does occur with some of the poorer designs.

Some receivers, such as the Murphy B40, AWA CR-6B and Hammarlund SP600JX-6 use variable capacitors which have ceramic shafts. [Pic013] These are very fragile and can sometimes be found fractured, especially if the radio has been dropped. In the event of unexpected tuning backlash in a newly acquired high quality receiver, this point is worth checking. It is usually possible to effect repairs by using Araldite.

7.12 Scaleplates

If your translucent scaleplate or meter plate is already darkened by age, do not attempt to compensate for this by fitting a huge bulb immediately behind it. It has proved possible to replicate a blackened cursor disc for a Collins 75A-3 by using 0.05" translucent white model making plastic sheet cut exactly to size, with a quite separate, newly manufactured scale mounted directly in front of it. The scale was generated at 1:1 size on a professional CAD system. It was plotted in colour ink onto conventional plastic acetate (Mylar) drafting film, and then cut to size with scissors. The new scale was lightly tacked to the plastic support disc at a few places around the edge with Bostik, which is fairly transparent when dry. The end result was indistinguishable from the real thing when viewed through the front panel window.

7.13 Optical Projection Systems and Filmstrip Scales

German and Russian equipment made widespread use of projection techniques. [Pic014] This technique was also seen on some Eddystone and RCA radios.

It is important to use the correct type of bulb, which sometimes has a non-standard filament orientation, or a very precise mechanical construction. Sometimes a bulb alignment adjustment was provided to get the filament in exactly the right place.

The projection may be of images marked onto a glass drum or disc, and is usually presented on a ground glass strip or plate. Some very ingenious arrangements were made, many of which gave a quasi-linear presentation of markings originally made in a circular format. The technique is efficient in the use of space and very reliable in service.

Filmstrip scales were introduced by Airmec, and immortalised by the RA17. These early designs were copied (usually with less success) by a host of imitators. [Pic015] Provided the filmstrip is clean and undamaged, little usually goes wrong provided the sprocketry is serviceable and provided the spring tensioning arrangements are properly adjusted.

It is absolutely essential to have properly functioning endstops with filmstrip scales, and this has been responsible for more design and service failures than any other feature.

7.14 Screening & Insulation Structures

Screening covers over RF sections are frequently located by a large number of 3/48UNC, 6BA or similar setscrews, all of which must be present and correct during alignment. On some radios, the RCA AR8516L being an example, very weak fastenings were used to hold the radio together and to hold the covers in position. [Pic016] Any highly stressed small brass screws could usefully be replaced by stainless hardware.

Any insulating blocks or earthing straps connecting adjacent parts of the structure, must be present and properly fitted.

Paxolin or SRBP insulation plates and tag strips in thermally hot areas of the chassis are prone to decompose. [Pic017] Usually the first sign is delamination of the material, local dark brown colouration, or wrinkling of the surface. Replace as necessary, preferably with a new structure built from epoxy-fibreglass FR4 laminate. Examples of insulation plates usually found burned up, include the GEC BRT400D mains transformer cover, the Collins R-390 heat shield insulators near the 6082 HT regulator valves, and the RCA AR88D bias resistor tag board.

7.15 Cooling

Cooling arrangements need to be checked very carefully. In particular, the cabinet feet all need to be present and of at least the same height as the originals. Yes, the cabinet feet are critical cooling components! This is to promote airflow under the chassis which will maintain long term reliability and minimise local oscillator drift.

In the case of radios such as the Murphy B40 which are fitted with metal rollers or skids underneath, proper feet will have to be fitted anyway. [Pic018] This is to avoid severe damage to the surface upon which the radio is to rest. When fitting feet to these radios, consideration needs to be given to the height of the feet, and to the weight of the radio. When in service, the Murphy B40 had lots of air available due to the design of its anti-vibration mounting cradle. So a standoff of at least 15mm would seem reasonable.

Fans fitted to radio receivers are normally found only on high performance equipments such as those Nems-Clarkes with nuvistor front ends, or on radios designed for continuous service under tropical conditions. Fans have a limited life and should be replaced when necessary. Many types had lubrication cups or wicks which need to be kept properly lubricated. Given a choice, sleeve bearing types are generally quieter than ball bearing ones when the time comes for a replacement to be fitted.

Some of the valved radio designs which never had fans fitted as standard, can run extremely hot. The original Collins R-390 and all members of the GEC BRT400 family, come instantly to mind. If these sets are to run appreciable hours, it is worthwhile fitting a fan.

7.16 Control Knobs

These are often missing or damaged.

Removal can on occasions be incredibly difficult. The problems usually stem from one of three causes: damaged grubscrews, seizure of the knob onto the shaft, or severe scoring of the shaft.

Grubscrews can sometimes be drilled out, but this is often only practical where the knob is very close to the edge of the panel. Where the problem is a sheared segment on a flat-headed grubscrew, this approach cannot be used unless the opposing segment is also removed to give an approximately level surface for the twistdrill to bite into.

Damaged Allen and Bristol pattern grubscrews are self centring for the drill bit, but they can sometimes be removed more easily with a reverse-threaded stud remover. American grubscrews always seem to be made of much harder material than the usual flat-headed British ones.

Occasionally the knob will be found stuck fast, even after removal of its captivating screws. The obvious solution is to remove the shaft as well, so that repairs can be performed in the vice. Very often though, this is impossible. On these occasions it is necessary to decide up front, the extent to which brute force is to be used. Various techniques are available. It may be best to drive the knob further onto the shaft prior to any attempt at pulling it off, but be extremely careful in the case of collet knobs. It is generally inadvisable to lever against the panel, because of the near certainty of cosmetic damage. [Pic019] In desperation, this writer once used a miniature butane torch on the knob, with a fibreglass mat against the panel. The knob was quickly ruined, but at least it came off easily! The panel was unscathed, and the control shaft quickly cleaned up with some emery paper ready for a new knob which had been obtained for this purpose beforehand.

On radios with badly designed over-travel stops the tuning knob may have slipped round in service, especially if it has unusually large inertia, as on the Marconi Atalanta. Sometimes the wavechange detent is so strong that the bandchange knob suffers the same fate. The result can be that the shaft gets so severely scored that the knob cannot be removed after removal of its securing screws, even though it can spin freely on its shaft. This is because the shaft or the bore of the knob bush, or more likely both have become severely burred. Because of the size of the tuning knob, a hefty puller can sometimes be used. If mishandled, this can damage the over-travel clutch and the dialdrive mechanism, causing even more work. If the knob can be replaced or repaired, it may be worth drilling its centre to allow the jackshaft of the puller to bear directly on the end of the tuning shaft. When the set is rebuilt, make sure the shaft has no burrs, and tighten the grubscrew(s) hard. Then take care in the future.

Knobs which are taper seated, or which tighten down onto a wedge are best assembled onto the shaft with a trace of grease so that they will come off more easily next time. Do not over-tighten the securing screw!

Black bakelite knobs often have engraved arrows, letters or lines which were colour filled, often in white. The original colouring often wears off over the years, leaving the engraving unfilled. The original appearance may be restored quickly and easily by the use of a Kwikfyl crayon pencil. The various available colours can be useful in restoring the engraved panel legends, labels and warning signs. Completely remove all old colouring material from the engraved character with a blunted pin. Then refill the engraving with new Kwikfyl, applied with a candle. Remove surplus material immediately, with a clean rag. The alternative is to use a white enamel paint such as Humbrol. This is best applied by dropping it into the engraved characters from the end of a small pointed tool. [Pic020] After doing a complete letter or number group, wipe the surface clean with kitchen tissue. When the panel is completely dry, thoroughly clean its entire surface with a brass cleaning polish. This will remove any light smearing and leave the panel looking as good as it will get. In this application, enamel paint proves no more or less durable than Kwikfyl.

7.17 Printed Circuit Boards

Towards the end of the valve era these came into widespread use. Unfortunately, the substrate materials then available were very poor as regards mechanical strength, water absorption, dielectric strength, RF loss, dimensional stability, thermal survivability and track/substrate adhesion. Taken all in all, this is a rather damning list, and indicative of the problems nowadays found in restoration.

Methylated spirit can dissolve the silk screen component placement markings, and its water content can cause hidden tracking and arcing problems inside the PCB material if the unit is not dried for ages after the PCB assembly has been washed. Surgical spirit seems to cause fewer problems.

Many PCB etch patterns were lacquered on the print side after soldering. Often this stuff was coloured green. A special case is the so-called “conformal coating” sprayed onto military PCB assemblies, especially those destined for airborne use. This stuff was clear, and thicker than the ordinary commercial green film. Both of these types of coating often partially wash off during the cleaning process. It’s wise to scrape away the coatings where you will be soldering, to avoid ugly dry joints. After repairs have been completed you may wish to consider brushing (do not spray) a thin coat of clear gloss exterior grade polyurethane varnish over the print. The good points of this technique include preservation of the PCB appearance, the avoidance of Copper oxidation, and the extra support - albeit slight - given to the fragile Copper print. Bad points include difficulty in the event that further rework becomes necessary.

At first sight it may seem that the first-generation radial wire-ended components used in these equipments would cause few problems, but unfortunately this tends not to be the case. Heavy components like the bigger polyester capacitors in moulded cases often relied on being physically supported by the PCB, rather than being captivated by a P-clip as on earlier equipments. Modern components tend to be much smaller, with a reduced pitch spacing of the lead-out wires. When using today’s components as replacements for period types the inevitable wire doglegs look bad and the body of the components are usually left at some distance from the PCB surface, standing proud by perhaps 5mm. This can place too much strain on the print doughnuts in the longer term, often resulting in the appearance of an intermittent fault. This writer would advise a small bead of Araldite beneath each incorrectly-sized replacement component, to save the fragile print from having to take all the strain.

Nowadays it is recognised that for PCBs having print on only one side, it is good practice to cross-hatch all large solid areas. This avoids undue stress on the track/substrate bond which prevents buckling of the PCB at temperature extremes. In the days of valve radios this problem was not recognised or if it was, then it was not addressed. Many intermittent faults stem from long term thermal cycling of these early PCB structures, resulting in cracked Copper tracks. Beware in particular, large PCBs with output stages or rectifiers in the middle. Be even more suspicious if the PCB is horizontally mounted directly above the valves.

Rather than carry out extensive repair of a first-generation PCB assembly with much loose track, several missing doughnuts and some burned areas, this writer would advise the creation of a new PCB on FR4 epoxy-fibreglass substrate. [Pic021] Do not be tempted to waste your time with an etch-resistant pen. This would not yield a solution of sufficient quality for fitment to a professional receiver.

Production of a proper drawing package in the form of a Gerber file designed on a PC program is perfectly straightforward in the domestic environment, and manufacture of a batch of boards is not as expensive as most people seem to think. Perhaps your owner's club can be persuaded to commission a small batch, thus reducing the cost per board and helping fellow owners of your model. The only serious cost threat that this writer would identify, concerns through-plated holes and multilayer boards. However, these are extremely unlikely to be encountered in the types of equipment covered by this book.

The new PCB could be a straightforward mimic of the original, but this writer would advise that the print be roller tinned, all large ground plane areas cross-hatched, and that hole spacings should suit currently available components. It’s a good idea to put a component silk screen onto the board, even if there was not one on the original. All resistors, capacitors and valve sockets would normally be renewed as a matter of course. Ceramic or PTFE sockets would be used for the RF, oscillator and hot-running valves. All wound components including any RF chokes, would be the originals transferred from the existing board. There is a possible downside to this proposal. The lower RF losses of FR4 laminate & modern valve sockets at VHF, could lead to parasitic oscillation not found with the original PCB assembly. Be on the lookout for this, and have 10Ω resistors or ferrite beads at the ready.

The different dielectric constant of the new substrate, any changes in track width, length or thickness, and/or any difference in substrate thickness will affect track inductance and capacitance to ground. However, these effects have not been found to matter in practice, at least as regards HF receivers. This is because the components themselves really do determine the operation of the circuit. That is not the case at VHF where component sizes, exact positions and interconnection arrangements are all significant. For this reason, much greater care is required when working on VHF receivers.

7.18 Valve Sockets

On the chassis, check all valve sockets for contacts that do not grip the valve pin snugly. Be particularly wary of the side-contact family (CT8, type E). These suffer a variety of problems. A slightly tight fitting socket often causes the Copper rivets on the valve base to loosen, causing intermittent contact. [Pic022] On the other hand, a slightly loose fitting socket can also be a source of actual or latent intermittent faults. In the middle there may be a happy medium… but not usually, with this awful family of valves. Each individual contact comprises a hairpin spring leaf, the ends of which are supposed to be free to move with respect to each other, not firmly connected together by a lump of solder. This is a point worth checking carefully. Because little of the CT8 valve base stands proud of the socket when the valve is seated, it can be difficult to remove the valve except by pulling on its glass envelope. This is an unsafe practice, and of course there is every possibility of the bulb becoming loose in its base. Perhaps more commonly on removing CT8 valves from their sockets, the bottom edge of the metallizing becomes detached from the bakelite base, leaving the valve looking ragged edged. It certainly pays to make sure there are no bits of debris or loose metallizing, lying in the well of the bakelite moulding. The sockets for this family usually seem to have a marking pip at pin 7, which seems unusual considering the valve carries eight pins. Another peculiarity of CT8 valves is that the pin numbering advances anticlockwise as viewed from underneath the valve, which is the reverse of every other popular valve family.

Check also for contacts that have become a loose fit inside the overall socket insulation moulding. This problem tends to be specific to certain families, especially those B7G, B8A and B9A moulded composition sockets where each individual female contact comprises a piecepart resembling a miniature tuning fork. If your radio has these items fitted, it is definitely not a good idea to power the set without its valves because sometimes the individual contacts can be so free to move that adjacent connections touch each other. When reworking one of these sockets, be sure not to rigidify the wiring more than originally. This is to ensure the valve pins have the same amount of freedom to move in the valve socket as previously. Failure to do this can result in microphony, especially in sets with an integral loudspeaker. Or it can cause broken valve pins, if you are really unlucky.

Some sets are fitted with special sockets which positively locate the valve. This may be done to get the heat away, or to guarantee local oscillator performance under operational conditions. The Eddystone S770R/1 for example, uses standard McMurdo valve sockets in its RF unit but they are modified to suit the application. [Pic023] Two contacts for the EF95 RF amplifier V1 are replaced by special turned pieceparts.

Inspect the sockets of hot running valves and all barretters and output valves for signs of decomposition or dry joints. Rectifier sockets should additionally be inspected for evidence of flashovers or tracking paths leading from the anode pin to chassis, or more often between the anodes in the case of fullwave rectifiers.

Be especially careful with any valve sockets mounted directly on printed circuit boards. If replacement is necessary, always try to use ceramic or PTFE ones in these applications, especially for RF, oscillator, rectifier and power output stages. Having said this, it is wise to be a little careful when replacing the valve sockets of frame-grid valves. Replacement by a modern low-loss type can cause unexpected VHF instability to occur.

The acorn family (954, 955, and 956) of valves are usually seated in large ceramic bases which have strongly-sprung gripper contacts. [Pic024] Because of the fragility of the radial seals on these valves, it is important that the contacts mate correctly. For this reason, it is advisable to lightly oil each radial pin before insertion of the valve into its socket, then remove all traces with methylated spirit to avoid problems later on.

The B8A sockets used on rimlock valves need special care. Any rust can make the valve very hard to extract, which can cause the locating pip on the side of the glass envelope to snap clean off. Sometimes it is possible to push the valve out from underneath by shoving a small screwdriver up through the middle of the socket while rocking the valve slightly. Early versions of Philips B8As and all Ediswan Mazdas were fitted with metal bases that could corrode into the socket. These various problems contributed to a short production life for the B8A family, and they remain very unpopular nowadays.

7.19 Repair of Damaged Castings and Threads

Radios based on castings include many Eddystones, the Murphy B40 and much German and Russian equipment, as well as a lot of CNR sets. The castings may be of brass, Aluminium, or a Zinc alloy such as Mazak (better known in some markets as Zamak). They may be further subdivided into sand castings, gravity die castings, pressure die castings and investment (lost wax method) castings, in ascending order of quality.

Zinc and Mazak castings can suffer from a condition known as “zinc pest” in old age, especially if stored in damp conditions. The casting can literally disintegrate and crack away into a pile of fragments and dust. This completely wrecks the casting. The writer has never had to deal with this problem but there is a lot of information on the internet. The best answer would be to find an original casting in better condition, or repair the original with filler and perhaps some local machining. This latter option could greatly worsen the shielding effectiveness and also reduce the physical strength, but it may be a viable way ahead for a radio that will only be used for static display. For an old radio that needs complete structural integrity, perhaps because it lives inside a restored military vehicle, there seems no option other than the manufacture a new casting.

This writer believes that slightly bent castings are best left well alone unless of brass, which can stand a certain amount of resetting without much likelihood of cracking. In the event of a casting becoming cracked as a result of being dropped, or because of a failed attempt at straightening it, there are several options.

Be sure to remove fragile major components such as variable capacitors and valves before attempting any form of repair. The easiest method is to use Araldite to mechanically fill the crack, after drilling through the ends of it to relieve any stresses. This will prevent propagation of the fracture. To be fully effective in the longer term and to provide proper ground continuity, a repair like this may need to be backed up by fishplates which may be put into position first or afterwards, whichever is most practical.

In the event of cracked cast cabinet handles, whether repaired or otherwise, it is sensible to affix a warning label indicating the exact state of affairs. [Pic025] This way, other people can make up their own mind about what is safe and what is not, when their time comes to lift the radio.

Some radios use stumpy cylindrical spun-on bushes to attach male threaded studs to the front panel, typically for securing the front panel to the chassis. The GEC BRT400D and RCA AR88D radios were constructed this way. These bushes seem very strong in the direction of a straight axial pull. The conundrum is that they are often found sheared at the interface to the front panel, perhaps because they were not originally mounted quite square. The best repair found by the writer, is to drill through the front panel and then countersink the hole to accept a black M5 Allen-headed setscrew. Discard what's left of the original bush, and use a stack of plain washers to give the correct stand-off. This style of repair is not invisible from the front of the radio, but it is at least properly strong. Attempts at using araldite to re-attach the original bush to the back of the panel have never proved successful for this writer.

If you are determined to attempt to straighten a bent casting, it is wise to remove <u>all</u> components and wiring, and strip the casting down to the bare assembly first. Take all the paint off with a chemical stripper. Then measure the casting on a surface plate to assess the extent of deformity. Heat it gently and evenly with a blowtorch, being sure not to melt the material. Keep the heat applied whilst somebody else has a go at straightening it. Both of you should wear eye protection. Go a very little at a time, and stop periodically for the casting to cool, so that it can be checked for truth. Be prepared to spend ages. If necessary, anneal the casting from time to time to prevent cracking. To anneal an Aluminium casting, first rub it with soap and then heat it gently until the soap turns brown. Remember that Aluminium work-hardens, so do any re-setting etc immediately after the annealing process. In contrast, annealing brass is quite difficult as its colour changes only slightly before the material melts.

The measurement technique depends on the accuracy required, which in turn depends on whether the casting carries a precision subchassis or a big variable capacitor. Do not strive for perfection, unless you are very brave. When you are satisfied, the external surfaces can be filled and stopped, then repainted. Do not paint any areas where metal-to-metal contact is necessary for proper grounding.

You are advised not to attempt to close up the inevitable small gaps when the major components are offered up to the repaired casting. Tinplate or brass shims should be constructed to fit the major components perfectly into position without appreciable distortion.

Damaged threads in castings can be Helicoiled down to the original size. Alternatively, an over-size thread can be cut directly into the material with a plug tap. Whatever happens, be sure to get all the swarf out. For female casting threads that carry a stud insert, it may be possible to open out the casting thread and make up a special stepped stud to give an invisible repair.

Many RF covers are retained to bulkheads with screws which pick up on threaded nutserts or rivnuts. These are supposed to be captive to the bulkhead. Very often, one or more of them is found to be missing when the RF cover is removed. In this case, you can conduct a thorough search inside the screened compartment to make sure that the insert has not simply fallen out and is lying loose somewhere inside, waiting to cause problems in the future.

Given the availability of the right tool, new thread inserts are easy enough to fit although most are metric types nowadays. If you wish to retain the original BA or UNC securing screws, a matching hexagonal nut may be secured in position on the bulkhead using Araldite. [Pic026] Unfortunately, tapping a BA/UNC thread into a metric insert is impractical because the material is far too hard.

7.20 Fully Sealed Radios

Some receivers were fully sealed against water and dust ingress. At least, they were when new! Many of these designs were intended for tactical use by the armed forces. Good examples include the British R209 and the American Collins R-392 HF receivers. Because most such sets were fitted to tanks, Landrovers, halftracks or Jeeps, the construction had to be rugged in the extreme.

Army CNR sets were capable of operation over wide temperature ranges. For operational reasons, they were designed for use by an operator wearing arctic mittens and so chunky knobs were generally fitted. Many radios were installed in their host vehicles in positions which encouraged their use as toe holds. Therefore the front panels, knobs and windows had to be "boot proof". Nevertheless many surviving CNR sets are found in badly damaged condition. Be on the lookout in particular, for CNR sets which rattle or have huge dents or broken castings. Such sets have probably been dropped, and the internal damage will probably be far worse than you at first imagine.

Other waterproof sets were intended for marine use, and these include commercial types as well as Naval. Here, the standard of construction is better than normally found in other classes of equipment, but less robust than the military CNR types. The marine sets tended to be well looked after by the users, and by the maintainers as well.

In general, sealed radios with valves in run very hot because of the obvious lack of ventilation louvers, and most have led a very hard life indeed. At least no dust or grit will have got in. The extent of the required overhaul will depend on whether the seal has failed, allowing internal corrosion to develop. If it has, then most of the work will usually stem from this cause, especially on marine equipments.

The intricate mechanical design of sealed CNR sets will provide many challenges caused by interlocking structures and high component densities. Some of the better sets were modular. This makes them easier to repair if all the necessary connectors and umbilical patch cables are to hand. The unfortunate corollary is that sets designed this way often prove harder to repair than a straight chassis layout if no service harnesses are available. One thing to be on the look out for with all modular CNR sets is intermittent connectors caused by all the maintenance that had to be done over the years, to keep these complicated sets fully operational when in service.

Very much on the plus side for sealed equipments is the joy of opening one which has had intact sealing throughout its working life. The interior gleams like new and the chassis requires no cleaning at all. It must be said though, that the smell which escapes when the seal is first broken is often very unpleasant, especially if MFP doping has ever been sprayed on.

The seal itself is often in the form of one or two O-rings. These are commercially available in different sizes of round and a variety of rectangular cross-sections. A ring made from Viton material of about 60 Shore "A" durometer hardness would be a good starting point for most radios. Note however that if grossly overheated, this material produces Hydrofluoric acid, which is extremely corrosive. Therefore do not touch a Viton seal with a soldering iron. If necessary, sections of O-rings can be joined together, and proprietary kits are available to make this job reasonably easy. Clean the groove in the casting, and then lightly coat the new ring with MS4 silicone grease before fitting it.

Many bakelite fuseholders and connectors were physically located by large D-holes in the front panel casting, and then thoroughly coated in varnish to prevent even the slightest chance of movement whist in service. Renewing these pieceparts can be a daunting task. The technique used by this writer is to lie the radio face down on the bench, and then cover the seal area with nail varnish remover. After a five minute soaking, the ring nut can usually be persuaded to rotate.

Sets with silica gel desiccator cartridges should have this component present, and thoroughly dried-out at 130°C for 2h before resealing the case. [Pic027] The silica gel material is available as granules and as beads. The granules are best avoided, as smaller ones might find their way through the weave of the restraining basket or sock and escape into your radio. The beads tend to have a diameter of between 1mm and 2mm, and are thus far more suitable. Natural silica gel is a white material, but some types are dyed with an indicating colour which shows the change from dry to wet. If your desiccator cartridge has a viewing window, this gives an instant way of knowing whether the radio is dry or damp inside. A suitable tool for removal of the usual screw-in desiccator cartridge is a 12” try-square. Unless all of the control shaft O-rings are also renewed, the overall sealing of the radio will not be perfect. Therefore, drying of the desiccator needs to be an occasional preventative maintenance chore.

If the intention is to fit a restored set into a period Landrover, Jeep or wireless truck, then it needs to be borne in mind that the reason these sets were so robustly constructed in the first place, is that this is exactly what is needed for survival in such vehicles. For the radio to give full satisfaction, all restoration work must be of the highest possible standard. Proper military valve types should be fitted, and there must be no bits of debris floating around loose inside the cabinet. If the set was designed to be supported on an anti-vibration mounting, then this must be correctly fitted if it is to be properly effective. Any extra waterproofing arrangements and sunshades should also be present and correct. All mating connectors should be the correct types, and be soundly fitted to the cable, with all glands and waterproofing gaskets in place and fully functional.

7.21 Bowden Cables

In the context of old radios, Bowden Cables refer to mechanical coaxial cable assemblies used to transmit motion from one part of a chassis to another. Many continental radios used these devices to transmit linear motion to slide switches, and/or rotary motion to variable capacitors. The Philips company was a noted exponent of this technique, as may perhaps be expected.

The flexibility inherent in Bowden cables made for an easy way to transfer mechanical motion to a sprung subassembly such as a tuner head mounted on rubber grommets.

The type of mechanism used to transmit linear motion often contained bell cranks and rods as well as the Bowden cable. Usually the assembly was spring-loaded under tension. Excessive friction or congealed grease can cause the mechanism to jam, or fail to actuate over the full intended operating stroke. A weak spring can cause similar effects.

Bowden cables driving large pulleys often work in push-pull mode, which avoids the need for a strong tension spring. Philips used this type of arrangement to operate the tuning gangs on some of their radios, for example model 643A. In practice it all worked better than may be expected, with minimal backlash and no need for the tuning gang to be strongly located on its chassis mountings.

Philips fitted their chasses into a wide variety of different cabinets. Some had long horizontal tuning scales. Others had short ones. Maybe the tuning scale was vertical instead of horizontal. Perhaps it was rotary. The clever 2-stage drive system widely used by Philips ensured that as a complete chassis assembly, the gang was permanently connected to the tuning spindle by a Bowden cable. [Pic028] Final test could be performed in a consistent way irrespective of the destination cabinet style. Then by fitting an appropriately sized pointer drive pulley and bracketry to suit the overall mechanical scheme, the job of chassis/cabinet final assembly would have been greatly simplified.

Repair of Bowden cable assemblies depends on the extent of damage, rust and missing parts. There are no special rules except to ensure correct lubrication after cleaning and reassembly. Synthetic car engine oil is a good choice for stranded wire cabling. Where used instead of the metal type, this writer prefers to run textile

Bowden drive cords completely free of lubricant. Textile cords are usually found on tuning gangs, where it is important to use an insulating material to avoid circulating RF earth currents and frequency instability. MS3 grease is a good choice for bell crank bearings and slides.

7.22 Special Paints and Finishes

A wrinkled paint finish is used on several radios such as the GEC BRT400D and Eddystone S358X. Although special wrinkle finish aerosols are available in some territories, their use is not essential. Here is an alternative using only ordinary enamel paint: Without any primer or undercoat, spray a very light coat of paint and leave it for >24h. Now apply a heaver coat, and leave it for another >24h period. While you're working, do exactly the same on a gash piece of metal plate for use as a "control sample." An airbrush is now required. Fill its bottle with lacquer thinners. Then VERY LIGHTLY spray an area of the control sample, and wait for its paint to wrinkle. Several attempts may be necessary, spraying the thinners ever more heavily until the desired result is achieved. Then spray the same weight of lacquer thinners onto your radio, and wait >48h for it to dry thoroughly. It is not recommended to use heat to speed this process, to avoid flattening the paint finish.

Here are some hints to help identify the different types of metal plating in common use. Cadmium plating is a shiny orange surface used over steel. Alochrom plating is a matt yellow/gold surface used over Aluminium. Tinning is a white solder finish used over brass and steel, usually with a few surface ripples. Galvanizing is a matt grey finish used over steel; its surface starts off being fairly flat, but often becomes rough in a few years. Copper is often directly plated onto steel. Sometimes Nickel is plated over the top of the Copper, to give a very flat shiny white lustrous finish. On radios, Chromium plating is rarely seen except on steel handles and badges, where it is generally plated over Nickel to give a thin but extremely hard electric blue surface finish. Silver gives a soft shiny white finish which is very inclined to blacken with age. It is plated onto brass, and is most commonly found on Eddystones.

Plated finishes are very commonly seen on chassis plates, BFO boxes, screening cans and the like. For the sake of appearances, it is sometimes necessary to re-finish these items. Nowadays, this can cause a problem. Here in the UK, metal plating facilities are fast disappearing in response to recent tough safety regulations. Cadmium plating has all but disappeared from the market already. This writer has found that the local specialist clubs catering for restored vintage motorbikes & automobiles tend to know who can do what in your geographic area, so it may be worth making contact with one of these organisations sooner rather than later.

A partial repair to Alochrom can be achieved by simply wiping over the damaged surface with a cotton wool pad saturated in Alochrom dye. This is a cosmetic repair rather than a corrosion resistant repair, but has the advantage that it can be done in situ. Wash your hands afterwards!

Silver plating was used by Marconi and Eddystone amongst others. It tarnishes with age unless lacquered when new. Unlike other metals, the oxide of Silver is nearly as conductive as the metal itself, so there is little to be gained by polishing. Quite the reverse in fact. All polishing will achieve is a reduction in the depth of the highly conductive oxide. If it is desired to shine-up an oxidised Silver surface, a quick wipe over with a cotton wool pad carrying a very little Silver Nitrate ($AgNO_3$) will work nicely. This material is hazardous to health, however. A safer alternative may be to use some Goddard's Silver Dip.

Ordinary grey chassis paint was used by RME and National among others, and the rule seems to have been not to use any primer or undercoat. Corrosion is commonly seen underneath the surface, especially on radios that have been used at sea. From the viewpoint of functionality, the only places that really matter are grounding points, soldertags, variable capacitor mountings, bearing housings and the like. As long as these parts and the chassis areas they connect with are all made shiny and clean again, a dab of grey paint over the top will suffice. After all, that's how most of these sets were "repaired" whenever corrosion appeared during their service lives.

Many people have completely rebuilt their National HRO by stripping it down to the bare chassis, giving the metalwork a complete re-spray, and then rebuilding the entire radio from scratch. This of course, is fine from the viewpoint of functionality. But this writer argues that destroying originality in this way is not what restoration ought to be about. What can be saved from the original build should be saved, is his opinion.

7.23 Freeing Seized Screws

The writer has found only two approaches that actually work: shock, and heat. Forget penetrating oil and freezer aerosols, these are no good at all for old radios! You'll be needing a very sharp good quality screwdriver of exactly the right size, and a lot of determination. Whatever you do, avoid using too much torque for obvious reasons.

The first thing to try is a centre-punch right in the middle of the screw head. Wind it up good and tight. The blow will be delivered "the wrong way", thumping the screw into even closer contact with its panel or nut. After two or five punches, most screws will come out without too much bother.

Those that still won't come undone, or which are varnished into position or loctited, need gentle cooking before they will release. Put a large, very hot soldering iron right on the screw head. Feed in half an inch of flux-cored solder, to make a big shiny bead. Leave the iron in place for 10 seconds (which seems like ages) then quickly pull the iron away and try again with the screwdriver.

Still can't move it? Now is the time for a very careful review to see if there is any alternative to removal of the seized screw. If the decision is that it really must come out, it's time for a barbeque! Clear all componentry out of the way and get in there with a miniature butane torch. The type used to light gas cookers works well because the flame is localised, and the tip of the lighter can reach 6" or thereabouts. Try 5 seconds.

<u>8. Switches, Turrets and Coilpacks</u>

8.1 Rotary Wavechange Switches

Rotary switches often give trouble, especially oscillator range switching wafers made of paxolin. Check all contacts for correct operation. Be very careful indeed, if attempting to reset the tension or position of any of the spring contact fingers. All shaft grounding springs need to be correctly tensioned and lubricated.

Arcing of switch wafers is a problem which is common, and can be destructive. Scrubbing the switch wafer with WD40 is sometimes an effective cure.

On wafers that appear to have problems, it is a good idea to examine very carefully the rotor contact clipped to the hub of the wafer. If this does not rotate concentrically, the mating contact spring fingers will have no chance of following the rotor disc. This is a frequent cause of contacts weakening and springing apart slightly, causing intermittent faults. The rule is, get the rotor to run concentrically <u>before</u> resetting any of the contacts.

It is important to check that the rotary motion is carried in full, to the switch bank furthest from the detent mechanism. When properly detented, all the switch contacts should be in the middle of their wipe. Too much friction halfway along the shaft can cause it to wind up, leading to lack of rotary motion towards the rear. The source of friction may be in the wafers themselves, or in misaligned or under-lubricated bushes or grounding springs. If the shaft appears twisted along its length, it is permissible to judiciously reset it, using a pair of miniature adjustable spanners at the front and rear of the shaft.

RCA used a particularly poor type of double-articulated tongue & groove shaft coupler in their AR8516L model. This was intended to accommodate slight positional errors without loss of rotary motion. Being made entirely of a plastic material, electrical insulation of the input and output shafts was assured. But the design seems to have huge backlash, at least in old age. These couplers and others of this general design should be checked very carefully for unwanted slop. Repairs or substitutions may or may not prove possible.

The bellows type of coupler is excellent, provided the brass corrugations are not cracked. [Pic029] One of these can be used as a replacement for inferior original types, provided its diameter and length can be accommodated and electrical insulation between input and output shafts is not a requirement.

Spider couplings are usually not well suited to wavechange switches, because of the inability of the smaller ones to transmit large amounts of torque. Big spider couplings can be excellent though, if you have room for their large overall diameter. All of these types of coupler should be inspected for unexpected cracks in both the hub and the coupling diaphragm.

The detent mechanism used on wafer switches is usually found at the very front of the shaft very close to the operating knob, or right at the back on the rear chassis apron. Little can be done to overcome weakness of the springs due to ageing, other than to lubricate the undulating track and its rollers or balls with EP90 oil. This part of the wave switch was usually not intended to be dismantled. That does not stop them falling to pieces sometimes though, when the factory staking fails! Repairs can usually be effected, but there is no standard technique.

If the decision is taken to replace a wafer switch with a modern component which is physically different from the original (usually somewhat smaller and of less lossy material), experience shows it is best to remove the original assembly as a complete unit, unwiring only those connections necessary for this stage of dismantling. Then the new wafer switch assembly is pre-wired on the bench alongside the original, which is used as a model. Do not throw away the original switch bank until the new one is installed and working properly. You may be surprised how many screening plates and rotor grounding springs will be found necessary, so buy plenty beforehand. It is better to have a few unwanted parts in your junk drawer than an oscillating front end in your radio.

8.2 Rotary IF Switches

Wafer switches used to control IF bandwidth are broadly similar to band change switches, but there are a few points unique to this application. All contacts should be surveyed visually, in order to verify their integrity. This is because unlike waveband switches, a contact malfunction can be extremely non-obvious, and many subtle IF faults can be “adjusted out” by accident.

For similar reasons, it is worth paying extra special attention to the shaft grounding springs, as any problems here can lead to skewing of the IF response nose, which may not be immediately noticeable without access to a reference receiver or an IF wobbulator.

Neutralisation may also need adjustment if a switch assembly has been replaced by a replacement modern low-loss unit, especially in the case of high gain, high frequency IF stages.

It is recommended that all IFT canister securing screws be checked for tightness, as problems here can lead to unsatisfactory stop band performance, as well as intermittency over the temperature range. Check especially, any screws that carry solder tags wired to the IF wafer switch.

8.3 Turrets

Turret tuning mechanisms are to be seen in the Murphy B40, Redifon R145, R&S EK07, Hammarlund SP600, McMurdo DST100 and Collins 51S-1. Although generally trouble free, it is important to get the rotor contacts to mate centrally with the stator contacts. This means that the axial position of the drum needs to be correct, with zero endfloat. Usually, one end of the drum is supported by an adjustable bush bearing, while the other is spring-loaded by a wavy washer. Wherever turret grounding springs are supposed to be fitted, they should all be present, correctly tensioned and properly lubricated.

The drum detent arrangement needs to be checked, and reset as necessary to ensure that the drum infallibly comes to rest with the contacts at the centre of their wipe. On some radios it is possible to vary the rotational position of the drum with respect to its detent mechanism. This can be useful in aligning the wipe of the contacts, and in extreme cases, to avoid engaging the rotor contact with a burned area on the mating stator contact.

Some radios were designed to have their turret turned in one direction only. If working on one of these, do not remove the interlock/detent mechanism without being very careful.

It is generally necessary to ensure the assembly is between ranges prior to removal of the drum. Thus usually requires removal of the detent spring first.

Quite often the sprung contact leaves are found to be broken. New contacts can be fabricated from thin phosphor bronze sheet, and held in position with a brass collar prior to soldering. After the solder has cooled fully, the contact can be bent gently into exactly the right shape, or at least near enough to do the job. On most turret designs, access to the mating contacts is quite good, the Hammarlund SP600 being a noteworthy exception to this rule.

8.4 Interchangeable Coil Assemblies and Coilpacks

A range of interchangeable coilpacks was used by National in their HRO, and by Eddystone in their S358X/B34 and earlier models. In general, this approach is straightforward and the coilpacks are trouble-free to overhaul, provided each coilpack has a properly matching set of biscuits, and is not a hybrid made up from pieces of coilpacks taken from a selection of similar (but not identical) donor radios. National HRO owners in particular, should be careful. There are subtle differences between MX and 5T coilpacks which can cause unexpected tracking problems if not identified prior to alignment.

Eddystones seem to suffer from dirty and corroded contacts. National HROs suffer from broken rivets securing the spring finger contacts to the insulator blocks below the tuning gangs. [Pic037] This fault can be quite hard to repair in situ, although it is definitely possible without removal of the tuning gang.

An interesting engineering variant, the non-interchangeable rack mounted coilpack, was used by National in their NC100 range. This is best imagined as a form of “linearly developed” turret mechanism, and represented a dead-end development path. It had problems all of its own, such as the inability to access all of the chassis at once which made power supply distribution faults particularly hard to find; intermittent operation on some ranges because the (hidden from view) stator leaf springs were expected to do the detenting as well as the contacting; and severe headroom limitations for the components mounted on the main chassis underside. Access to the band change contacts is not too bad on this set, as individual biscuits can be removed from the rack after separating the two halves of the casting assembly. [Pic038] The dial pointer was designed to vary in length as the carriage moved from side to side in order to change ranges. The arrangement for doing this was bizarre and distinctly hard to adjust.

It is necessary to ensure that the carriage is between bands prior to its removal from the chassis. Broken contacts may be dealt with in the same way as for turrets, but because of the invisibility of the parts after reassembly it is necessary to use a dental mirror to inspect the mating of the contacts as the carriage is moved. This is quite fiddly.

8.5 Slide Switches

Slide switches have changed footprint quite a bit over the years. Sometimes, exact replacements for early types are impossible to find. Whilst this is rarely a problem for panel-mounted slide switches, there can be severe headaches in the case of PCB-mounted types. Often, the best way ahead is to salvage the baseplate from the original switch, and use it as the header for a new component mounted piggyback with its legs trimmed as short as possible or splayed apart, then soldered to the header. Deft work is required. If the new switch is slightly smaller than the old one, the overall dimensions of the new hybrid will be approximately the same as the original component.

In the event that the original switch has become loose on the board, or stiff in its operation, the connecting print doughnuts may have ripped. In this case, strengthening is necessary. Start by gluing the switch base plate to the top surface of the PCB substrate, prior to soldering. This task is often made difficult by the residue of lubricant which will have been applied over the years.

8.6 Toggle Switches

Switches carrying signals at low voltage and zero current need gold contacts to avoid developing high contact resistances. On wartime radios where this is a recurring problem because the switch contacts were of cheap material, it may be possible to introduce a bit of bleed current (say 2mA) through the original switch to keep it clean.

Certain open frame switches used on military equipment eg B40s, need frequent lubrication of the mechanism in order to ensure reliable opening and closing. [Pic039] This problem also occurs on some American equipment where a reliable break of the mains switch can sometimes not be guaranteed, a problem made potentially dangerous if the mains switching is single pole.

The slotted type of toggle switch often found mounted on a bracket on the BFO capacitor, and which is used to switch HT to the BFO can sometimes go open circuit due to burned contacts. Sometimes these can be renovated by immersion in paraffin, or worst case by stripping and cleaning. On other occasions it is worth trying to mount the original slotted dolly onto a new switch body. The writer has successfully transplanted the slotted dolly from an SPST HRO Arrow wartime switch into an Arrow DPDT switch body from the 1970s. [Pic040] This process created a BFO/AGC switch suitable for a McMurdo DST100.

8.7 Potentiometer Switches

This section deals with the switches mounted piggyback on potentiometers. The only problems of note are seen on American sets which use switches comprising a rotating paxolin or SRBP disc which carries studs. The pivots get stiff or the springs get weak, with the result that the mechanism seizes or the contacts fail to engage properly.

On one Hallicrafters SX28, the switch on the noise limiter would click convincingly but not actually make or break reliably, even after careful lubrication. This same fault was also seen on an original replacement switch which was then fitted as a swap for the first one! In the end, a modern replacement had to be used, a great shame since this component is at the top of the chassis and extremely visible from above.

Avoid the common mistake of automatically assuming these switches are all normally-closed, going open circuit when set to the anticlockwise click position. In the Collins KWM-2 will be found a perfectly ordinary looking potentiometer-mounted switch that does the exact opposite.

9. Wound Components and Wiring

9.1 Initial Inspection

Where they appear undamaged and have reasonable conductivity, wound components and wiring may be presumed innocent until proven guilty. Pay particular attention towards the top of the chassis, where temperatures are highest. This is where insulation decay starts first. Look for gooey, hardened or fried wiring, cracked wax coatings, and wax drips due to overheating.

Pay extra attention to IFT bobbins carrying an overwinding which forms part of a switched selectivity arrangement. Often on the GEC BRT400, the insulation between the two windings can flash over as the set warms up, destroying the next IF valve. [Pic041] This problem occurs most often when receiving a good signal with the RF and IF gain wound right up, and the AGC switched off.

9.2 Screw Cores

Iron cores come in two basic types with a variety of grades to cover different applications. They have a wide range of relative permeability.

True ferrites are shiny, and coloured either charcoal or black. They have a high to exceptionally high value of relative permeability, and are best suited to LF and MF work.

Powdered Iron cores are usually matt grey. These have a lower but still positive value of relative permeability, and are well suited to HF and VHF applications. For both ferrite and powdered Iron types, the coil resonant frequency will drop as the core is inserted.

Brass and Aluminium cores are sometimes found in VHF/UHF equipment. The resonant frequency rises as the core is inserted into the coil.

It is important to ensure that each coil has the correct type of core, and that the length of the core is as originally specified by the manufacturer. Usually, coil assemblies that look untouched need not be investigated further. Coils that look to have been the source of past problems should be surveyed to see if the right type of core is fitted. This can be difficult without reference to a gold standard radio.

As a first step in sorting out the wound RF/IF components on your radio, move all screwed cores very slightly to prove that they do in fact rotate, and that the coil formers remain fixed in position while this is performed. Then carefully reset the cores to their original positions. It is often a good idea to record the depth to which each core is recessed into its former, using a vernier calliper.

Cores that do not move as they should can cause major headaches. Before attempting anything potentially hazardous to the health of the former or its windings, some basic measurements need to be made so that if the need arises, the coil assembly can be replicated. The complete coil assembly should be removed from the chassis. Disconnect any capacitors, and measure each winding in turn with all other windings disconnected, to determine their individual inductances. Note the wire gauge, wire type and the relative sense of all windings. Then if possible, measure the mutual inductance. Note whether the windings are lap wound, wave wound, pile wound, or a mixture of these. Finally, be sure to measure the length and diameter of each bobbin, and record the physical distance between the windings. Take pictures.

Many IFTs etc have two cores. Very often, the bottom one will move whereas the top core won't. In this case it's a good idea to remove the bottom core first, using the correct trimtool. Now try to remove the top core downwards, all the way through the former and out of the bottom. This approach relies on the lower face of the top core having an undamaged screwdriver slot. Any small pieces of core material left behind can be pricked out as the last part of the job. If you're unlucky and both cores are damaged or jammed solid, carefully saw the IFT in half and unscrew both cores towards the middle of the former to remove them.

The most troublesome cores are those which have a hollow hexagonal bore. These cores look very robust but actually, they are very prone to shearing longitudinally. The plastic trim tool must always be fully engaged with the core when adjustments are being made. Removal techniques for jammed or broken cores include eating away at the material with a small drill, or creating a new screwdriver slot by scraping the surface with a scriber. In the case of hex cores it is sometimes possible to drift one of the broken flutes down and out of the coil former, after which the others can usually be removed very easily by careful use of a hatpin.

Cores that are loose in their formers may be held in position by a length of elastic filament, or if extremely loose they can be wound with PTFE plumbing tape before insertion.

9.3 Mains Arrangements

Routinely check the integrity of all mains wiring and insulation using a proper Megger or other high voltage insulation tester. [Pic068] Do not try this test using a DMM, as the results may indicate the equipment to be safe when in fact it is not. If in doubt, take the radio to somewhere equipped with a calibrated PAT machine. You could try your local tool hire shop.

If a single pole mains switch is fitted to 230V-only equipment and you are not going to use an outboard isolating transformer all of the time, then you are advised to change the switch to a properly rated double pole type even if this destroys originality. Review the voltage rating of any mains input filter capacitors that may be found, especially on American radios.

Some designs of mains switch cannot be relied upon to break cleanly. The Eddystone S358X, Murphy B40 and Collins R-390 are all distinctly prone to this fault. For this reason, the writer likes to switch power externally on all old radios, rather than rely on the front panel control.

Always fit a new mains cable conforming to current electrical practice and renew all fuses, even if they appear undamaged. Mains fuses would ordinarily have a value of typically three times the steady-state RMS current drain when operating at maximum HF and IF gain under no signal conditions. Use the correct fuse value, where this is known.

American radios are often supported by handbooks written only for the home market, where the transformer had a single 117V primary. The export sets were often referred to as the "universal" models. (Warning: in the UK this term would usually mean an AC/DC variant). When operating American universal sets from 234V, the mains fuse should normally be halved in value compared with the figure in the book.

In the case of universal American radios fitted with a simple unshuttered slide voltage selector switch, and a single pole mains switch, this writer would recommend operating the set on 115V via an autotransformer. This avoids excessive stress on the transformer and wiring insulation, and on the mains filter where fitted. It is often an easier route towards modern safety standards than changing the mains switch. This policy also avoids disaster in the event of the selector slide switch accidentally being moved during restoration or servicing. Alternatively, the voltage selector can somehow be locked in the high voltage position. [Pic042] If an isolating transformer is available, then it is certainly wise to use it. Confusion with 230V supplies is easily avoided by using a deliberately different family of connectors for your 115V radios. There must be absolutely no possibility of these low voltage radios being plugged directly into the household 230V mains, of course!

Change cable grommets where they have hardened, even if this is highly inconvenient to do.

Many awful types of mains chassis connectors have been used over the years. [Pic043] Strip out anything suspicious and fit modern components, even if this further worsens originality. What's at stake is worth far more than mere cosmetics.

You might like to make sure the main chassis of your radio is earthed, even if originally it was not designed to be. For AC/DC sets, or other live chassis designs referred to <u>in the UK</u> as "universal" radios, it is possible to use an outboard isolation transformer to achieve this objective.

This writer advises that in all cases, the mains tap be set 5% above the prevailing mains line voltage.

When the set is first running, keep an eye on the mains transformer temperature. These things can run warm, or on some American radios, hot. They should never smell or smoke, or have core temperatures exceeding +90ºC. The large thermal mass means that the transformer core temperature may take two hours to stabilise.

In the case of so-called "line cord" radios, which were mostly cheap American midget domestic or enthusiast sets, measure the mains cord resistance carefully, examine the condition of the insulation and take the right decision about its future. The original length of line cord cannot be shortened. Do not simply replace the line cord with ordinary mains cable, and be especially careful with the mains plug connections of these sets. Some had two wires to be connected to the Live pin, one to the Neutral and none to the Earth. All too often, the chassis of the radio went live as the set was switched off, a thoroughly nasty characteristic. This writer is inclined to condemn line cord radios on sight, but fully acknowledges their collectability.

In the writer's own collection, all pre-war mains radios are routinely modified to have an over-voltage varistor wired directly across the power input. The more delicate old sets then have an appropriate negative temperature coefficient thermistor fitted in series from there on into the radio. For example the Brimar "Brimistor" type CZ1 is rated to pass 300mA, at which it will develop 44Ω of resistance compared with 3kΩ at room temperature. This arrangement will hopefully protect the old and fragile mains transformer from grossly excessive mains transients, and allow a slightly easier warm-up for the bulbs and filaments every time the radio is switched on from cold. Care is needed because the thermistor may reach some 250°C when running, so its leads need to be left ¾" long and the component allowed good ventilation.

9.4 HT Insulation

On American radios, especially Hammarlund SP600s, measure the insulation resistance of all HT smoothing chokes. These sometimes have excessive leakage to frame, on occasions less than 20kΩ. This disease is progressive, and not curable by inaction. It is curable by replacement/rewinding, or by insulating the choke frame from chassis using stepped plastic bushes. If using the latter technique, record it on a prominent label tied to the choke frame, to avoid a later owner finding the unwanted side effect of your solution unexpectedly, whilst working on the chassis.

9.5 Re-impregnation

Re-impregnation of wound components is sometimes needed. IF and RF transformers having wax insulation may have progressively lost unloaded Q over the years, due to increases in the dielectric losses caused by water absorption. RCA AR88Ds often suffer from this problem, which causes an asymmetrical IF response which cannot be wholly corrected by adjustment. In this case, the component must be baked dry before resealing with a suitable impervious paraffin wax. Not all waxes are suitable, and period literature indicates big differences between the types then available. This writer is unable to offer meaningful advice, except that the correct stuff is definitely a type of paraffin wax, and not any other kind despite claims from time to time in the press that beeswax is satisfactory.

1950s mains transformers, smoothing chokes and AF output transformers were often sealed with bitumen. This stuff tends to flake off and make a mess. [Pic044] There are two alternative methods of repair. Either the component can be resealed in a boiling tar bucket (be sure to leave it in the goo for at least a quarter of an hour), or else all the loose bits can be prised off and the bald patches then painted with a bitumen based sealer paint. The former method is to be preferred, but may be rather less convenient. Fumes from boiling tar buckets may not be welcomed in your domestic environment, unless there are roofing repairs to be done as well!

9.6 Wiring and Looms

Rubber wiring may be found brittle or the exact opposite, gooey. In general the rubber will be in worst condition at the top of the chassis, where the temperatures are highest. So look at the wiring to dial lamps and high mounted switches/potentiometers first.

In the case of radios using rubber or canvas screened cable to feed the LO grid cap, it is strongly recommended that this cable be replaced by one having a PTFE dielectric such as RG316/U coaxial cable. [Pic045] This is often an easy way to improve the frequency thermal stability because of a greatly improved temperature coefficient of capacitance, which is especially important in this application because such screened cables run right to the top of the hot valve envelope. By similar logic, changing the screened cables feeding the RF amplifier valve grid caps can give increased image rejection on the HF ranges because of reduced dielectric losses.

A nice alternative to changing the entire screened cable is to run the original insulated inner out of its jacket braid, and then thread in a replacement insulated wire. Again, PTFE is to be preferred, but even PVC insulated cable will be a huge improvement over a rubber original. Repairing the screened cable this way has the benefit of retaining the original external appearance. [Pic046] This technique can also be used to mend coaxes and screened cables which have developed short circuits between the inner and outer conductors. This is especially likely to happen at the connections to valve top caps.

Plastic wiring can go brittle with age, especially where it has been heavily doped with an MFP compound. Sometimes shorts develop between different PVC insulated conductors in the loom, if it had been laced too tightly when new. This is because PVC is a plastic material which creeps out of the way in time, leaving the conductors exposed.

PTFE will only occasionally be found on radios of the valve era, but the comments regarding creep are even more relevant to this material. PTFE has the added problem of being very easily nicked by the knife whilst being prepared for tinning, or by sharp metal edges whilst the loom is being positioned in the chassis.

Varnished canvas and fibreglass insulated wire rarely gives any trouble at all.

In the case of transformers and chokes that have doubtful looking insulated wires emerging through an unbushed hole in the metal screening cover, it is a good idea to varnish the wires at the point of entry. This can keep the component in service when otherwise it may eventually need rewinding or at the very least, internally re-terminating in a few years time.

British radios were sometimes assembled using “solder barrels” to group the component leads together, rather than tagstrips. PSEI and KW were among the manufacturers favouring this technique. Each solder barrel typically comprises an 80mm length of 22swg TCW wound tightly round & round a 3mm twistdrill to form a hollow metal cylinder about 3mm diameter and 4mm long, into which the component leads are stuffed. The barrel is then filled with solder, and the excess lead lengths clipped off. The easiest way to change components is to use thick solderwick to remove all excess solder from the barrel, then slide it off the end of all the component leads. Change the failed component, then slide the barrel back into place and resolder it. With practice this process becomes quick and easy. This writer finds that working on radios that use solder buckets is far easier and more pleasant than doing battle with conventional tagstrips or Collins vector turrets.

If your chassis needs rewiring, first make a realistic assessment of the extent of the necessary repair. Prod the insulation of individual wires along the length of the looms, using a small screwdriver. The insulation should give way and then spring back. If it does not move, the insulation is too hard, and possibly brittle. If it does not spring back, it has probably gone too soft.

If an entire loom has to be replaced, clip each wire at its termination, release all the P-clips and then lift the loom gently out as a complete assembly. Draw it carefully at 1:1 scale on a big piece of hardboard. Don’t take the loom to pieces to do this! Then drill holes in the hardboard, corresponding to where each individual branch wire leaves the main cableform. Replicate the loom on the bench using suitable modern wire, poked through all the holes you have just made. You now will have all the wires staying in the same relative position as on the original cableform. Keep the hardboard pushed up close to where you will be lacing. Be sure to leave each wire end about 15mm longer than originally. This is partly to make good the shortfall in end lengths caused by the cable form being snipped off rather than unsoldered, and partly to allow each wire to be re-made one more time if necessary, without the pigtail becoming too short.

Still on the bench, bundle the new loom initially with tywraps, and then lace it properly with new braided nylon cord or string. Start at one end, and remove each tywrap as you go along. This work is not difficult, but will be time consuming if you have never done it before. Be patient, and work carefully. Aim for perfection. This is one job where you <u>can</u> achieve it, given time. Each loop should be independently knotted. Do not use tywraps or spiral wrap anywhere on the final loom. These things look awful inside an old radio, and are very eye-catching.

Do not be tempted to re-route the loom somewhere easier to fit. It was designed to go exactly where you found it, very possibly as a result of parasitic instability found by the design team when the loom was put in the more obvious position.

Remove all solder and old wire ends from the various connecting lugs on the chassis. Then strip and tin the cable ends of the new loom, and offer it up into position on the chassis. If you have done your work properly, the new loom will fit perfectly. [Pic102] Reuse the original P-clips if you can. If not, fit new ones.

If only partial rewiring is needed, snip each loop of the lacing cord back as far as you need to go, and carefully feed out the old rotten or burnt wiring complete with its lacing. It is best to remove complete wires if possible. Then fit new wires into the loom. Where joins are essential in mid-loom, use a Hellermann sleeve to cover each solder joint. Everything has to be done in situ, which is why the use of heat shrink sleeving cannot be recommended. End by re-lacing the loom using the original positions for each loop of the cord. Partial repair of a loom like this very often takes longer than fabrication and installation of an entire new loom assembly, and never looks half as good. Except in the case of very localised damage, this writer recommends complete replacement of damaged looms, every time.

Suitable wire for most radios will be PVC covered 16/0.2mm for signal and HT circuits, 24/0.2mm for runs feeding up to 3 filaments, and 63/0.2mm for high current runs to the filament transformer of a big receiver. Umbilical power cables for the Eddystone S358X, National HRO etc should use 63/0.2mm for the filament, and 24/0.2mm for HT+ and HT ground return, the latter ideally doubled-up. The colour brown looks unobtrusive in most radios.

One curious feature of Collins and Marconi radios is that they used screened cables that had no insulating sleeve over the braid. It is obviously necessary to take particular care not to let the braiding fray, or lie against any live metalwork.

9.7 Motors

These are principally found driving the auto-tune mechanisms in military radios, and AFC mechanisms in SSB adaptors.

Most motors can easily be rebuilt to re-seat or replace seized or worn brushes. With a little ingenuity, helped by a press and a good model making lathe, the bearings can usually be renewed too.

Most problems occur not with the motor itself, but with the driven mechanism. As a rule of thumb, a worn motor will indicate a much more severely worn gear train. Indeed, before purchase of a motor-tuned radio it is well worth a good search for metal filings near the driven gears. You can form your own conclusions, if many are found.

Electrical noise is usually due to brush wear, failure of the suppressor component(s), or failure of one diode in the driver rectifier bridge. The result can be extreme deafness of the radio during tuning, something which can be puzzling when first encountered, especially if the radio has a squelch system.

9.8 IFTs

The primary of the first IFT may have a higher impedance than the other IF windings in the set. This is especially likely with radios using a 6K8 or Ediswan Mazda 6C9 mixer, and was considered necessary to give the best conversion gain with these types.

In contrast, the windings of the final IFT may have lower than usual impedances in order to efficiently drive the usual AGC and signal detector diodes, which present low impedance loads.

For the reasons given above, it is necessary to exercise care when fitting IFTs taken from a radio of different type from the one being repaired.

On those radios with switched selectivity, multiple windings are often used. Sometimes these take the form of an overwinding on one bobbin, whose phase may be reversed by switching to select either of two mutual inductances. Overwindings sometimes short out to the main bobbin, a particular problem on the GEC BRT400 series of radios.

An alternative technique was used by Eddystone, who used variable selectivity by physically changing the position of one winding inside each IFT. [Pic091] This arrangement works very well in practice.

9.9 Battery Wiring

On battery sets of American origin, wiring may be found labelled "A" (heater), "B" (HT) and "C" (grid bias). Various voltages were in common use and it will be necessary to identify which voltages go where on the chassis.

Whatever country of origin applies to your radio, the battery connections will be by special connectors which are often found badly corroded. The cabinet or battery case will often also need attention.

9.10 Audio Transformers

Inter-stage transformers were sometimes excited by a parallel feed (often called parafeed) arrangement which used RC coupling to keep DC out of the primary. This enabled a smaller and cheaper Iron core to be used in the transformer.

In battery sets, QPP output stages would normally use a step-up driver transformer to feed drive voltage into the high impedance control grids of the output pentodes. In contrast, class B sets would use a step-down type to drive positive grid current into zero-bias triodes. Both of the transformers here will ordinarily be of the unbalanced to balanced type.

Output transformers are distinctly prone to flashovers across the primary, and from primary to frame. More dangerous are flashovers between primary and secondary, especially in those cases where the output winding is left floating or only lightly connected into a negative feedback circuit. To reduce the risk of flashovers, output transformers should never be run without a load. Short circuit loads are generally safe, but open circuits are generally not.

Many output transformers are protected by a shunt resistor or capacitor, or by a Zobel network. The capacitors need to be able to tolerate high AC voltages; and if the cold end is grounded, they must withstand the applied HT voltage too. That's why so many of them go dead short, and destroy the transformer primary.

9.11 RF Chokes

HT RFCs are generally trouble-free except where the winding has become loose, or where there is evidence of overheating due to a past short circuit somewhere downstream in the power feed system. A single dab of clear polyurethane varnish is often sufficient to anchor a wayward winding to its former. In contrast, the overheating problem may prove far more serious than is at first obvious. When passing grossly excessive current, the invisible centre of the RFC winding will get far hotter than the outer layer. So an RF choke that looks barely overheated may in fact be well cooked inside. It may be suffering from shorted turns, or even be completely open circuit. To link the two topics covered in this paragraph, the writer has seen a loose bobbin as the only surviving evidence of a fault which at some time past must have fried the winding of an RFC and destroyed its adhesive bond. There was no visible evidence, but the unusually low winding resistance confirmed the suspicion of short circuited turns. On another occasion it was only the slight difference in colour of one particular RFC compared with all the rest, which indicated a possible problem. That choke looked perfect, but it crumbled to dust as soon as it was prodded.

If the HT system in your radio uses several examples of a particular type of RFC, it is easy to make resistance comparisons if you become suspicious about one of them. Or you could add an additional 47µH in series with the original component as an experiment. If this makes a significant change to the radio performance, then the original RFC may well be defective. The resistance of the replacement choke is not generally important, but the inductance certainly needs to be similar to the original. In the case of an RFC feeding HT into an LO, mixer or BFO stage, or where the RFC is used to prevent parasitic oscillation it may also be important to aim for at least the original SRF value.

On mains-powered radios, heater RFCs generally cause fewer problems than do HT RFCs. The only exception seems to be those sets having a lot of dial illumination bulbs to go wrong. For example on the GEC BRT400, it is common to find that the bulb wiring loom is fried. Depending on exactly where all that short circuit LT current went, one or more heater RFCs may have suffered along the way.

In the case of battery-powered sets, the filament RFCs are usually critical to the general radio behaviour. These chokes must be correct not only as regards inductance, but also as regards resistance. As with HT chokes the SRF value can also be important, especially in LO, mixer or BFO stages.

10. Thermionic and Other Active Components

10.1 Criteria for Selection of Valves

On grounds of reliability, longevity and consistency/accuracy of characteristics, this writer would advise that you use valves made in UK, Canada, Germany, France, Sweden, USA or Japan. Valves made in India, Mexico, China, Brazil and Spain generally deserve suspicion because they are often of very inferior quality.

Russian valves are enigmatic. The standard commercial types tend to be poor quality and unreliable. However, the same type number suffixed EB denotes a long life commercial variant and suffix EP denotes a full military specification combined with a long life cathode. These -EB and -EP valves are often excellent. For example the writer would not advise fitting ordinary Russian commercial type 6n14n to replace a hard-working EL84 in a GEC BRT400K, but a 6n14n-EB or 6n14n-EP would do the job adequately.

Care is needed with the pinout of Russian valves, which is not always as expected. Unlike most (all?) Mullard EL84s for example, the 6n14n family makes no connection to pin 1 inside the glass envelope. In the case of the two EL84s used in the GEC BRT400K, pin 1 of the valve socket is not wired, so there would be no problem. But the fact is that some radios designed around Mullard valves rely on an internal G1 connection existing between pins 1 and 2, and may therefore operate incorrectly with a 6n14n. This is despite the Mullard EL84 specification stating that although pin 1 may be used for internal connections within the valve, it should not be used for external circuit connections!

A slightly different problem is found with the Russian 6k4n, which is often sold as directly equivalent to the popular 6BA6/EF93 used in RF and IF amplifiers. The 6k4n has an internal connection between G3 and cathode whereas the genuine 6BA6/EF93 does not; and the 6k4n glass envelope is noticeably taller. Do these differences matter? Well, that depends on what the valve is used for, how the socket is wired, and whether the Russian 6k4n will fit into the space.

While discussing non-standard valves, the writer has an unusual EL84 and ECH81. Both have Russian-style sharp shiny pins, and both are branded Raytheon. These valves are of course forgeries. They have much fatter glass bulbs than normal and will not fit inside the usual spring clips or valvecans. These two valves appear very well made, which was an unexpected surprise! The origin of these valves is not known to the writer.

Valves from Taiwan (ROC) and South Korea are generally okay and don't give much trouble. The ones from mainland China (PRC) seem strongly polarized. The writer has seen very good and very bad, but does not have enough experience to offer a useful opinion. Caveat emptor!

The British CV100 series of valves was a straightforward coding exercise. These are standard commercial valves, given a military number for procurement purposes. A CV140 is no more reliable or better built than an ordinary EB91, for example.

For VFOs and hot running applications such as output valves or rectifiers, you may be well advised to consider the use of high quality types even where not originally specified for your radio. Full-military examples such as USA four digit types (5749 etc) or the UK CV4000 series are very desirable here, not least to reduce microphony. The commercial/industrial uprated types can also be a good choice. To aid identification, the high class Mullards were designated SQ (Special Quality). The STC/Brimar (later Thorn/Brimar) valves were called Trustworthy, mostly with a triangular yellow/black adhesive or the same symbol printed directly onto the glass. The Raytheon CK-prefix, GE Five-Star, Motorola Golden and RCA Command series of valves fall firmly into this category. So does the Sylvania Gold Brand range which had no additional strengthening put into their design, but many of these special Sylvanias had Gold-plated pins and were extremely well made. Marconi/Osram made very special quality versions of many standard valves, for example the A3283 is a strengthened long-life variant of the N37 output pentode. AWA produced their Super Radiotron range of highly reliable valves. Care is needed with some of the heater current ratings for these high quality valves. For example, the 6135 and GL-6265 both have a 175mA heater instead of the usual 150mA for the equivalent commercial types 6C4 and 6BH6. This was done to achieve more reliable operation under adverse voltage conditions, but it may cause heater current imbalance in radios with series/parallel heater wiring. For example the Collins R-390 uses both of these types of valve with a 26VAC primary distribution system for the heater strings, so care is certainly needed.

Telecom valves in the CV5000 series used by the UK Post Office and the SER "Longlife" range made for LM Ericsson are unusually long-lived in static service, but these valves were not designed for repeated warm-ups or to survive high levels of vehicular vibration.

In general, the American military suffix-W valves are much more robust than the average commercial grade, though not necessarily any more long-lived in fixed applications.

The WA, WB suffix American military valves will each safely replace lesser suffices, but the converse is not true. For instance, a 6AU6WC will replace a 6AU6, 6AU6WA or 6AU6WB in all applications, but a 6AU6WA will only replace a 6AU6 and should never be used to replace a 6AU6WB or 6AU6WC. Some of the suffix upgrades affected secondary parameters such as warm-up time, heater/cathode insulation withstanding voltage, or the mechanical resonant frequency of the electrode structure.

Warm-up time, mutual conductance, gas current and heater/cathode insulation may all be valid selection criteria. The application will determine their order of importance. The one thing that ought not to be allowed to matter too much is the external appearance of the valve, as long as its gettering is not miniscule, milky or brown/black.

Sometimes a valve may be encountered with Gold plated pins. This is a very visible and obvious sign of constructional quality. A popular example in the radio world is the E180F, used as mixers in the Racal RA17/117 series. However, a word of caution is in order. Taking as an example the low noise E88CC-01 (often found marked E88CC/01), many specimens from the cheaper suppliers lack the Gold plating. This is because they are actually nothing more than an ordinary commercial ECC88 branded as E88CC-01, and not the real thing at all.

Frame grid valves have an extremely small spacing (only 0.001" in some types) between the cathode and the innermost grid, which is usually the control grid. This was necessary to obtain very high mutual conductance. An unwanted side effect of this construction is that these valves are far more sensitive to mishandling or electrical damage than ordinary types, and they seem noticeably more prone to develop intermittent faults in service. Special care is needed when testing frame grid valves. It is not always safe to apply more than 100V between control grid and cathode on a valve testing machine. See the Tung-Sol 6KD8 datasheet for an elaboration of this point.

Valves of the frame grid type, and certain others such as the 6SG7 and 7H7 are prone to develop control grid emission if the heater voltage is too high. This problem can cause very poor AGC action if the affected valve is somewhere in the RF or IF amplifier chain.

With side-contact valves (CT8, type E), it is important to make sure the valve base has no loose contact rivets.

Occasionally it will be found that a suffix Y octal valve is called up in American equipment. This signifies a type with a low loss base usually of made of woodflour- or mica-loaded phenolic material, coloured brown. Sometimes ceramic bases were fitted to valves made by Raytheon and Hytron, a sign of obvious quality.

Valves fitted to receiver RF units should be thoroughly tested to ensure the absence of any inter-electrode shorts prior to their fitment in the chassis, because of the invariable difficulty of access to this area of the chassis.

Caution is advised with the GT (glass tubular) family of valves. Some of these had moulded bases of larger diameter than the standard G (shouldered glass) type, and will not fit inside skirted octal sockets. This confusion was removed by the eventual introduction of the GT/G suffix. This denoted a variant which could replace both the G and the GT in all applications. The same comment about not fitting into skirted sockets also applies to metal valves of course, with the added problem of ensuring the metal envelope is properly grounded for safety and to ensure proper electrostatic screening.

Many of the GT signal valves had a Nickel-plated brass collar around the base. This was grounded to pin 1, and was intended to accept a tubular screening can. Many of these metal collars are nowadays suffering from season cracking, which results in a long split running the complete length of the collar from top to bottom. Usually, the valve itself works fine but the reliable connection to the valvecan is lost and of course the appearance is dreadful.

In France, the MG series of metal-glass octal valves was developed and sold by local manufacturers such as Adzam, Neotron, Mazda (not Ediswan) and Philips. [Pic047] These valves were the same height as the G types but tubular, and clad in an integral close fitting Aluminium jacket. Confusingly, the French also fitted a metal jacket to their GT valves. Thus both the 6Q7MG and 6Q7MGT are tubular and metal clad, the only difference being the height. Towards the end of production some MG valves released by Visseaux were just plain ordinary GT valves with a metal-sprayed outer coating, making a complete nonsense of the French coding system and showing utter disregard for product quality and the company's reputation.

When ordering replacement valves, it is wise to be aware that many valves were made in different envelope styles without any change in type number. As examples, the RCA 80 rectifier and the Mullard EBC33 dual diode triode were both available in shouldered and tubular glass styles over the years. The standard Mullard ECH35 had a metallized shouldered glass envelope but this valve was also available in unmetallized form as RAF type VR99A. Some late-production military ECH35s came in a tubular envelope, just to complicate the situation. If paying good money for a new valve, it is worth checking that it will at the very least fit properly in the available space, and won't cause unexpected short circuits or look out of place.

A lot has been written about testing valves. The writer likes to test them on a simple Taylor model 45C because this measures mA/V, which is the only sensible way of assessing signal valves of the type found in radio receivers. Some types oscillate strongly when operating on this valve tester. This is especially true of large high-slope valves such as the KT66, and small UHF types such as the PC900. The writer has a large ferrite ring which fits over the B7G envelope and often stops the problem. Care is needed.

Forgeries abound. Here in the UK, the most commonly encountered fakes are those branded United Electron, Raytheon, Standard, IEC, International Servicemaster, AEL, CEI, Amperex, Tung-Sol, Telefunken and Mullard. Viewed from a UK perspective, the valve types most commonly faked seem to be KT66,

5881, ECH81, 6BA6, GZ34, 7591, ECC189, GZ33/37, 5U4G & E84L. It's as well to pay far more attention to etched markings on the glass than to any printing. Boxes are best completely disregarded because these are forged even more commonly than the valves themselves. It's a depressing picture for the future of our hobby. If in any doubt, keep your wallet firmly shut.

10.2 Valve End of Life Definition and Reliability

The following information is taken from RMA Standard ET-107 which specifies typical end of life limits for a valve is running at rated heater or filament power:

RF & IF amplifiers: 65% of rated mutual conductance.
Mixers & product detectors: 50% of rated conversion conductance.
Local oscillators, BFOs & calibrators: 65% of rated grid current value.
General purpose triodes: 50% of rated mutual conductance.
Output valves: 50% of rated output power.
Diodes: 40% of rated direct current value.
Rectifiers: 80% of rated output voltage under load.
RC-coupled amplifiers: 70% of normal AC output voltage.

As a generalisation, big valves are more reliable than small valves because the electrode structures run cooler. Several of the spacious wartime and immediate post-war radios were updated over the years to use smaller valves, usually by way of simple adaptor plates for the valve sockets. Examples include the Murphy B40C/B40D, the GEC BRT400D/BRT400K [Pic105] and the AME 7G1680BA/7G1680MA. The updated sets tended to be full of 6BA6, 6BE6, ECH81, 6AT6 & EL90 valves instead of the earlier 6K7, 6SA7, ECH35, 6Q7, 6V6 etc varieties. Sure enough, more 6BA6s need to be changed than 6K7s nowadays even though the younger age of the updated equipment often leads to better reliability overall.

Some of the last valved equipment achieved a level of component packing density that restricted airflow and resulted in high operating temperatures. Fans were sometimes necessary to avoid reliability problems in service.

The anodes of some top quality output valves and rectifiers were sometimes given a dab of heat-disclosing paint. This was done to enforce the manufacturer's warranty policy, and to help engineers identify dissipation problems. The STC 5B/255M (a loctal 6L6 variant) has one paint spot on either side of the anode, in the very hottest places. If the colour is still white, the valve has not seen much service. If grey, the valve has run very warm. If the spots have completely blackened, then the valve has been well & truly thrashed.

Shiny valvecans were often fitted because they provide effective screening whilst at the same time being cheap to buy. Simply changing these for blackened types or heatsink cans can lead to improved reliability for the valve.

Valves tend to end their days by developing gas problems, going low emission or noisy, losing mutual conductance, developing heater-cathode shorts, or generating grid emission. Some of them develop glass faults caused by cracking of the base seals, or go intermittent because of defective spotwelds or fraying grid windings. Inter-electrode shorts can develop. Top caps come loose. Occasionally, the cathode gets stripped of its oxide because of a huge flashover, or the cathode's connecting strap gets burned through like a piece of fusewire. Overly-hot output valves and rectifiers sometimes melt the glass envelope, which then gets sucked-in until it touches the anode. The gettering can fail as shown by discoloration, a reduction in size, turning milky or in extreme cases disappearing altogether. Open circuited heaters are fairly common. There are many failure modes! The writer's opinion is that good quality NOS valves give far less trouble than cheap modern reproductions. By keeping them cool and making sure the important surrounding components are in good order, most valves will give good service in your radio.

10.3 Valve Fabrication, Repair and Remanufacture

Bearing in mind that so many of the older valve types were basically common bulb/electrode assemblies mounted onto a family of alternative bases, it may be possible to make what's effectively a new valve if you have a source of donor parts. This writer has successfully grafted the bulb/electrode assembly from a new spare octal Brimar 6F6G onto the UX base from a defunct RCA 43 to create a 42; and converted an octal AZ31 into a side-contact AZ1 using the base from a dud ECH3. The work is rather fiddly, and you must perform a comprehensive set of tests to verify that there are no inter-electrode shorts before you put the "new" valve into service. The best way to remove the bulb from an octal base is to start by loosening it rotationally, wearing gloves and goggles and with all parts of the valve held inside a big rag in case of breakage. Then one by one, gently bend each pin in the bakelite moulding back and forth until it snaps at the root, making sure each wire remains attached to its pin. Then melt the solder at the end of each snapped pin and pull it free of the wire. The next step is to paint the end of each wire in a distinctive way so that it can be uniquely identified later on. After doing this 8 times or as necessary, the old bakelite base should pull straight off. Then the bottom of the bulb can be cleaned up, and all wires extended and sleeved as necessary ready for insertion into the new base. Araldite works fine for the bond, but do be careful in the case of magic eyes to align the bulb onto the base in the correct angular position. A careful check on a valve tester will confirm that you have connected the wires to the new valve base pins in the right order.

Cathode rejuvenation works a few times on valves with thoriated Tungsten filaments, which of course are mainly transmitting types. Some success may be obtained with oxide coated cathodes at the risk of deterioration of the heater/cathode insulation, a worsening of the gas level, and/or the possibility of the filament becoming open circuit. Three minutes at double the normal filament voltage is worth trying as a first step, with no other voltages applied to the valve.

Several proprietary rejuvenators were available, though these were mainly intended to work with cathode ray display tubes. Their use with receiving valves is strictly in the experimental category athough some success may be expected, particularly with poisoned calibrator valves and VHF front end valves such as ECC85s on receivers that have rarely been powered-up because the radio was always used on Medium Wave.

Be careful when attempting to rejuvenate frame grid valves. The very close grid-cathode spacing on these types makes them intolerant of even small changes in cathode geometry caused by structural warping due to excess heat.

Types UL41 and to a lesser extent EL41 are prone to developing resistive paths between the control grid and nearby electrodes, most problematically the heater and screen grid. The results are audio hum and standing positive control grid voltage respectively. Ordinarily, either problem would condemn the valve. But it may be possible to blast a clear path by applying a high voltage between G1 and all other electrodes. The writer has tried this only once, using 200V. That particular UL41 was an old Tungsram, and there was a definite improvement after the surgery. The reason the UL41 fares worse than the EL41 is because of the high heater voltage combined with the effect of the series heater string, which usually results in the "hot" end of the filament being some 100V above chassis potential. An improvement can sometimes be made by swapping the wiring to the two heater pins on the valve socket.

In the case of those valves that are no longer obtainable from anywhere at any price, or where cathode rejuvenation is inappropriate, repair of the original valve is the only logical alternative to the manufacture of a new one unless rewiring of the socket for a slightly different type is considered acceptable. Many faults, such as a broken cathode connecting strap, or a heater wire that has snapped at its weld to the pinch lead-out wire would appear to be very simple to repair given the necessary trepanning, welding, pumping and gettering equipment. The writer would very much welcome contact with anyone having experience of this type of work. Unlike large transmitting tubes, the valves used in receivers were never designed to be rebuilt after a period of service. Hence the envelope glass may well be a type fundamentally unsuited to repair.

10.4 Loose Top Caps and Valve bases

Loose top caps are best unsoldered and removed. Clean the cement surface, but do not attempt to dig it out unless it is loose, in which case be sure to remove all unattached pieces. Then apply a bead of Araldite to the pip without disturbing the lie of the wire, which is quite fragile. Immediately refit the cap, push it home and quickly solder it. Do not disturb the assembly for a day or so.

The term “valve base” is easily the least confusing of the various names used for the bakelite base forming the bottom part of many older style valves, and which carries the male connecting pins or protruding side-contact lugs. They are found on standard glass octal, tubular octal, UX, British, CT8 etc valves.

The best way to fix a loose base is to invert the valve, squirt some Evostik through one of the spare holes in the bakelite, then try to swill it round a bit. Finally, store the valve upside down with an elastic band squeezing the bulb into its base for a couple of days. Any adhesive that dribbles through the gap between envelope and valve base, can be trimmed off with a scalpel after it has set. A slightly more unsightly repair for use mainly when the valve has no spare pin holes, is to run a thin fillet of Evostik between the bulb and the valve base. Then apply the elastic band and store the valve the right way up for a day or so. If using this technique, you are recommended not to attempt trimming of surplus adhesive, because it will leave a mess and weaken the joint.

The MOD often used a short length of large diameter grey self-adhesive heatshrink sleeving to securely join the bulb to the bakelite base of some types of output valves and rectifiers. Valves commonly seen with this fitment include the 5U4G, 5R4G, 6V6G and 6F6G. The writer believes that it was not only used valves that were given this treatment, many new valves were given the grey heatshrink before they were fitted for the first time. Although it does not look good, this simple technique appears to be 100% effective in preventing loosening of the bulb/base joint.

10.5 Carbonizing and Metallized Coatings

In the early days of radio it was common to find valves with beautiful glass envelopes coloured silver, gold, blue or pink depending on what material had been used as the getter, and depending on the wishes of the manufacturer’s marketing department.

Moving to a later age, many valves used on communications receivers were constructed with a plain grey carbonizing wash (“aquadag”) on the inside of the glass bulb. RCA, Osram and Brimar valves manufactured in the 1940s, 1950s and early 1960s were often carbonized. The claim was made that it assisted heat dissipation from the valve, and prevented dark blue fluorescence caused by secondary emission from the inside of the bulb at points where it was bombarded by stray electrons from the electrode structure. In later years improved anode coatings became available, and the carbonising wash ceased in production. Thus a post-1962 MOV KT66 can be identified by its transparent glass, whereas the KT66s of earlier decades were heavily carbonized to a greater or lesser extent depending on the exact date of manufacture. Mullard used a grey carbonizing wash on some valves (VR99A, EL32) and a blue heat dissipating ink on others (EF91). The blue coating stopped in the 1970s. Pre-war, Philips had used a thin inky blue coating on the bulb of early-production EFM1 magic eyes for a completely different purpose: to improve the viewing contrast. After the first year of EFM1 production, ordinary clear glass was used instead. So much for that idea, then!

External metallizing using a Zinc spray was primarily an attempt at avoiding the need for a separate screening can, but some companies used it to hide the dirty internal appearance of their valves. That was especially true of those manufactured using the Azide (Barium vapour) process, which produced valve structures so messy that ordinary mica insulators could not be used. Metallizing came in many colours. Here is an application list which is no doubt incomplete:

Silver/Grey: Telefunken, Ediswan Mazda, Cossor, Dario, Gecovalve, Loewe-Opta, Mullard, OSW, Tungsram, Visseaux, Tesla, RSD, STC, Matsushita, HF, RFT, Siemens, Osram, Marconi, TeKaDe, Grammont, Ever-Ready, Majestic, Triotron, Pressler, Sator, Ediswan, Rogers, CIFTE, Europa, Klangfilm, Philips, Zaerix, Stabilovolt, Marathon, Ekco, Radio Record, Miniwatt, RWN Neuhaus, Arctron, RVC, Thermion, Zeiss Ikon, Phonetika, DGL, AEG, Valvo, Oxytron, Haltron, Chelmer, Vatea, Raytheon, Hoges.

Black: Rogers, Loewe-Opta, Siemens, RWN Neuhaus, Oxytron, RCA, RFT, Telefunken.

Gold: Valvo, Tungsram, Mullard, Philips, Ever-Ready, Visseaux, Dario, SER, Triotron, Telefunken, Neotron, Siemens, RT, Hivac, Loewe-Opta, Ultron, Castilla, Raytheon, Svetlana, Ferranti, Miniwatt, Novis, TeKaDe, Longlife, Hoges, Oxytron, Pope, Thermion, Vatea, Bentron, RVC, Grammont, SIF.
Red: Philips, Tungsram, Valvo, Dario, Ediswan Mazda, Ever-Ready, Triotron, Adzam, Zaerix, Bentley, Pinnacle, Chelmer, Teonex, Amperex, Novis, Osram, Ultron, Tesla, Haltron, Miniwatt, RCA, Pope, Neotron, Marconi, Telefunken, Sator, Cifte, Belvu.
Blue: Ediswan Mazda, Visseaux.
Brown: Vatea.
Green: Ediswan Mazda, Toshiba.

Metallized valves need to have a complete coating, so far as it originally went. Some types, for instance the Ediswan Mazda 6P25 and the Philips EBL1, had a metallized coating extending only part of the way up the bulb and part of the way down the bakelite base. Any patches of metallizing found loosely adhering to the glass or bakelite should be wire-brushed off. Then touch-up the metallizing with a suitable conducting paint such as the (surprisingly expensive) Silver-bearing material sold for repairing car heated windscreen elements. Any gross areas of missing metallization can be covered in Aluminium cooking foil and then "painted-in" with the conductive paint. Don't forget to coat the wire ring or spring clip that connects to the shield pin in the valve base! When this new layer of conducting paint is dry, it is a good idea to mask the metallizing overall and then over-paint with a single coat of suitably coloured high temperature paint. The stuff sold for use on central heating radiators or car exhaust manifolds works well for this job. The new paint will improve appearances, and prevent further degradation of the metallized coating in years to come.

There is a special problem with metallized valves fitted onto side-contact CT8 sockets. If pieces of metallizing material come loose, they often fall into the valve socket and disappear from view. Shorts between adjacent contacts are a common result.

Silver-grey external coatings are very prone to peeling off, especially if the valve has been stored in conditions of high humidity, or if the valve is a particularly hot-running type. To make things worse, this type of coating can get so dirty as to completely obscure the markings of a VP41, AC/VP1 etc. The gold, black and red metallized coatings were much better in both respects.

Cleaning of the metallization can be performed quite effectively, using a toilet cleaner such as Harpic. Care is needed when handling this stuff. Wash it all off the valve carefully afterwards because it is highly conductive and corrosive.

The metallized coating should be well grounded. Even a few ohms can cause instability in RF and IF stages.

Because the metallizing is very brittle and because the earth contact wire or clip is captive to the valve base, it is obviously necessary to make sure the bulb is not at all loose in its base. If it is, fix this problem before attempting to restore the connection from the valve base shield pin to the metallized coating.

If your chassis uses an entire family of metallized valves that look much the same (EK32, EF39, EBC33 etc), then mark each valve in some way so it can infallibly be fitted in the correct socket. This is best done by scribing the underside of the valve base, where the marking cannot be seen. Do not use a pencil, because this may cause tracking.

Wherever metallized valves were originally specified, they should be fitted. However, beware of using metal or metallized variants where they were not originally installed. The shield pin on the valve socket may sometimes have been used by the factory as an HT anchoring lug. British manufacturers in particular, were inclined to do this rather than fit a separate insulated tag. The PSEI H52 domestic receiver was designed to use an unmetallized Marconi DH63 double-diode triode. It so happens that this type of valve was available with and without metallizing under exactly the same part number. If a metallized specimen is plugged in, the outer coating is at HT and thus hazardous to the service engineer.

10.6 Valvecans and Retainers

On most old radios, valvecans are usually fitted somewhere or other. They are all there for a purpose, therefore they should all be fitted - except in some American equipments such as the Collins R-390A, where certain specified cans should be removed for static rack mounted service. Check the handbook to find out which valves should have cans fitted, for your particular type of installation.

Do not assume that valvecans should always be fitted wherever a skirted valve socket is to be found. This is not always so. The 12BY7A transmitter driver valve in the Yaesu FT101 family is a good example.

The ordinary shiny Aluminium or Nickel-plated brass valvecan is not at all friendly to the valve. Blackened cans are much better, giving a lower anode temperature under adverse conditions of operation. You might wish to consider an upgrade to blackened cans for ethical reasons, especially if you intend to use your radio a lot or it uses rare or fragile valves. Cans were made in brass and Aluminium. The brass ones are much heavier and of higher quality.

Fluted or ventilated cans were often fitted to neons, barretters and hot-running output valves. If these special cans are supposed to be fitted, then it's usually a good idea to fit them.

Red cans are often of heavy µ-metal material. They were sometimes fitted to valves operating at high audio sensitivity such as the EF86 to reduce hum, or to valves which are susceptible to AC magnetic fields such as the 7360 mixer where the objective was to reduce hum-modulation of the signal. Another application was on battery-powered radios fitted with integral loudspeakers. The static magnetic leakage field from the magnet could damage certain of the more fragile B7G 1.4V filament types. Don't get confused by red-painted valves with integral metal cases, though! Sylvania made red EF50s that were no different to the many unpainted examples; and RCA made a series of unusually robust red octals such as the 5691, 5692 & 5693 that were not antimagnetic in any way.

The Hammarlund SP600JX-6 uses a bespoke can for its 6C4 first local oscillator valve. This has a special brazed-on lug which must be screwed down onto a support pillar, to provide proper mechanical support and to guarantee efficient grounding of the can. [Pic052] The objective was to improve frequency stability and possibly also, to reduce local oscillator radiation. To further promote local oscillator stability, it is a good idea to fit a highly robust type 6135 in this position, if available.

The best cans for B7G and B9A valves are the contact-cooled types made by IERC such as the TRNC6000 family, which was licence-manufactured by Garrard in the UK. These can sometimes be fitted as an upgrade in place of the standard type. It is a good plan to avoid fitting contact-cooled cans to barretters or neons, though. Marconi was quite fond of using an elaborate fully screened can which contained woven wire wool to support the valve envelope and take the heat away. These cans screwed down onto a special threaded ring which surrounded the valve socket. They cannot be used as replacements for ordinary valvecans. One side effect of all these cans is to feed heat from the bulb to the skirt of the valve socket, and hence down onto the chassis. This is generally not a problem. However, care is needed with VFOs, which may drift more with a heatsink can than they do without because of increased component heating near the valve socket. Another relevant fact is that for miniature valves without an internal shield around the anode cylinder (eg type EF91), heatsink cans increase the anode capacitance to ground compared with ordinary bayonet types.

Certain American radios used spring finger stock inside B7G and B9A valve socket skirts, presumably to support the valve and promote cooling. If originally fitted, all such hardware should be present and correct. Make sure none of the little spring prongs has become detached and fallen on to the top of the valve socket insulator, or got jammed alongside one of the socket contacts. This problem is frequently encountered and can be a puzzling source of short circuits.

Some radios by Philips and Heathkit and perhaps others, used push-on cans which connected to a grounded metal finger running up alongside the valve envelope. Sometimes the finger was intended to be trapped between the valve and its can, and sometimes it pressed onto the can from the outside. In either case, it is important to make sure the can is properly grounded, so that it acts as an effective RF shield.

Spring valve retainers generally give little trouble if made entirely of metal. Some of the types intended for balloon top valves have a woven basket at the top of long side springs. These do not go wrong either. In contrast, retainers using a pair of helical springs and simple knotted fibreglass or cotton string are a source of constant trouble. It must be possible to repair these things when the string breaks, but this writer has never succeeded in doing so.

The Marconi B8G series (eg X81, W81, DH81, KT81) and B9B series (eg EF50, EF54) valves used all-metal valve retainers which often need new side springs. Other than rust, little else ever seems to go wrong with this pattern.

10.7 RF Amplifiers

RF amplifier valves need to be selected primarily for high mutual conductance. A valve tester is fine for this job. Use the gainiest valve you have as the first RF amplifier. Be wary of using a later design of valve to get more HF sensitivity. In the main, any benefit achieved will be small, but the risk of VHF parasitic oscillation will be large. Similarly, be careful of using a semi-remote cut-off valve in a design originally based around a wide grid base variable-µ valve. There may be slightly more ultimate HF sensitivity to be had, but this time it will probably be achieved at the expense of strong signal handling.

The worst option of all would be the use of a straight frame grid valve such as an EF95 to replace a big old variable-µ standard octal type such as a 6K7G. The difference in capacitances and mutual conductance between these two families is so great that correct tuning would be difficult to achieve on the HF bands, at least with adequate stability. Even if this condition were obtainable, the AGC performance would now be very poor because the front end would be trying to perform almost the whole of the variable gain function on its own whilst lacking the intrinsic linearity to cope properly under strong signal conditions.

Having said all of this, some radios certainly do benefit from a modest plug-in upgrade. For example, the SP600JX-6 gives 10dB NF on 6m with a 6DC6, compared with 12dB with the original 6BA6 front end. No circuit changes are needed, the stage is totally stable under any conditions of source impedance, and the two-signal performance is only slightly worsened. It is likely that types 6JH6 or 6BZ6 would be even better substitutes because of the slightly longer AGC tails of these valves.

In designs that use high gain or frame grid construction front ends such as 6CB6, 6DC6 and 6BZ6, the valve will often be found distinctly flat, giving poor HF sensitivity and worsened intermodulation performance. These high performance valves also seem more prone to inter-electrode shorts than lower gain types with larger electrode separations, especially when the valve envelope is mounted horizontally in a way which allows sagging of the electrode structure.

Looking at the octal and B8B long tail standard RF pentode families, the 6SG7/7H7 is noticeably quieter than the KTW61/6K7/7A7/W81. Best of all is the EF39/EF22/CV303. These Philips types are very good indeed, with ENR values of only 6.2kΩ. In comparison, the much later 6BA6 managed only 3.7kΩ - which just goes to prove that some octals were nearly as good as the all-glass miniatures.

Some of the more advanced full-size pentode types such as 6AB7 and especially EF50, 6AC7 & 717A are noticeably quieter than the long tail standard octal types, but at the expense of worse strong signal handling ability.

American wartime radios which are supposed to be fitted with suffix Y octal valves having biscuit coloured low loss woodflour-loaded phenolic bases, should always have this type fitted in order to avoid deafness at the higher frequencies.

The ECC189/CV5331/6ES8 twin-triode cascode RF amplifier had a period of vogue. It was used in receivers such as Eddystone models EA12, S940C & S880/2, the Racal RA17L & RA117 and in late versions of the G2DAF design. This valve is a variable-µ version of type E88CC, which therefore cannot be used as a direct replacement. The ECC189 gives excellent performance as an AGC-controlled HF RF amplifier, offering extremely good resistance to blocking and cross-modulation effects. Ediswan-Mazda type 30L15 was a similar valve, mostly seen in VHF TV tuners. It is not pin compatible with the ECC189 and has a different heater voltage requirement.

10.8 Acorns and Nuvistors

Acorns and nuvistors had a period of vogue in American professional radios, mainly HF/VHF and UHF types made by the likes of Hallicrafters, Watkins Johnson and Nems-Clark. [Pic054] The good news is that these devices are very reliable indeed, and give a reasonable service life.

Most types of acorn are still commercially available.

The main problem with acorns is fractured radial seals, caused by excessively forceful attempts at insertion into the socket. The best way to avoid this risk is to oil each radial pin before insertion, then wash it straight off with methylated spirit after the valve has seated home.

Nuvistors generally come at extremely high prices, because so many still remain in active service. If all the nuvistors in your radio are present and serviceable, then sit tight and hope for the best! In the meantime do not disturb them, but start laying in a cautious stock of spares.

If any pentode nuvistors are missing, and direct replacements are not traceable or affordable, you may wish to consider the use of an available miniature wire-ended glass type such as a 5840/EF732 (straight) or CV4503/EF731 (variable-μ) with legs bent to fit into the original socket. The new valve will be taller than the original, so support it at the top of the envelope using a rubber grommet. Keep the wires very short, but do not bend them within 1.5mm of the glass seal. Be particularly careful not to damage the valve socket, otherwise you may have problems fitting a new nuvistor, if you manage to get one later on. It may prove possible to open the old broken nuvistor and use its bottom end to anchor the new component.

Some nuvistor front ends were blower cooled. In such cases it is important that the blower works properly and that all airflow ducting plates, gaskets etc are present and correct. If fitted, the airflow intake filter should be inspected and cleaned.

At the risk of being branded a heretic, this writer would point out that it may be possible to use cascoded 2N3823 & 2N4882 N-channel JFETs to replace acorns or nuvistors. For a little while, Teledyne & Fairchild produced pin compatible non-thermionic replacements for certain common professional valves. These devices were called “Fetrons”. The list of available types was small, but included the 6CW4, 6CB6A, 6AM6, 6AK5, 12AT7 and 12AX7. Care is needed to ground the can of the Fetron. An example part number is TS6AM6 from Teledyne Philbrick Nexus, which was a general-purpose plug-in replacement for the standard 6AM6/EF91/CV4014. When used in an oscillator circuit, it may be necessary to add a clamp diode and/or an RC network to replicate the grid-cathode characteristic of the original thermionic device. Some types of Fetron contained these additional components internally.

10.9 Compactrons

These were used in some American radios but not for long, and their production life seems to have been quite short.

Compactrons were really three or more valve sections inside one large tubular glass envelope fitted with 12 little pins. [Pic053] The supply situation seems to be very variable, so the writer recommends owners of radios using these things to build up a good stock of spares. Compactrons seem rather prone to developing heater-cathode shorts, which is a nuisance. The multiple electrode structures can cause gas problems. It is wise to be on the look out for this in compactrons containing hot running sections used as output stages, especially when another section in the same envelope is used for a negative voltage high impedance application such as AGC detection or VOX amplification.

10.10 Mixers

The key to healthy mixer operation is to use the right valve - not a near equivalent - and feed it with the right amount of local oscillator injection. Too much excitation causes whistles. Too little causes a lack of conversion gain, and hence low sensitivity. Although multi-electrode mixers have rather complicated surrounding circuitry, surprisingly little usually goes wrong with them and most types remain widely available. The octal 6A8, 6C31, 6K8, 6J8, ECH35, 6TH8G, 6E8, X61M, X65 & X66 types are all broadly interchangeable despite detail differences in electrode constructions. Types CCH35 and OM10 are extremely similar to type ECH35, but drawing 200mA heater current instead of 300mA. Special care is needed with type 6TH8G as this is a physically large device which draws no less than 700mA of heater current. The Ediswan Mazda 6C31 is even thirstier, although it is at least in a sensible GT envelope! Care is also needed with type 6A8, as its HF performance is rather poor. In event of unexpected deafness, it may be worth checking that a 6A8 has not been fitted in place of the superior type originally specified for your radio. The 6SA7/6SB7Y and 6L7 heptode types are deliberately not listed since the mechanism of their operation is very different from the other valves, and from each other. In addition, these valves are not pin compatible with the other common octal mixers.

In the loctal family the 7J7, ECH22 and X81 are broadly interchangeable, with the 7S7 providing better performance than any of these. Early examples of type X81 had a metal locating spigot. This was changed to black plastic halfway through production. The late type gives better performance in the GEC BRT400D in respect of LO pulling on the HF range. The ECH22 was also available with its cathode connected to the metal locating spigot and a different pinout, as type ECH21.

The Ediswan Mazda 6C9 and the far more common ECH42 are also broadly interchangeable, though these types have very different heater current ratings. Some adjustment may need to be made to the triode grid resistor value if this substitution is made. Note that the American 6C9 is an entirely different valve from the British Ediswan Mazda, the latter being constructed as a sort of miniaturised 6K8 with an over-current heater.

The commercially successful 6SA7 was developed into the miniature 6BE6, which became an extremely common sight in American radios. The only real technical difference between these two types is the shape of the innermost grid winding. It is a plain cylinder on the 6SA7, but formed into a cathode-hugging shape on the 6BE6 to give better oscillator performance.

Staying on the original octal base the 6SA7 was developed into the 6SB7Y, which was popular for only a few years before obsolescence. The 6SB7Y had a brown coloured phenolic base loaded with ground mica and woodflour, to lower RF losses. It also had an improved electrode structure, allowing better HF performance from an oscillator section of higher mutual conductance than the 6SA7. In later years the electrode structure of the 6SB7Y was fitted inside a miniature B9A envelope to create mixer type 6BA7, as used by Collins in their 75A-4. This heptode was so good that it was usable on FM Band II, but it never became really popular because of the early arrival of type ECC85, which was cheaper and quieter.

There are a lot of CV2128s on the market, originally boxed for the MOD by Mullard. This type is claimed to be equivalent to the commercial ECH81. In reality, some CV2128s carry Philips manufacturing code NJ (=ECH83) whereas other equally genuine CV2128s are coded YD (=ECH81). The writer has examples of both types; and all of them work fine in applications where an ECH81 is specified. One caution is that many of the available CV2128s bear Philips codes for Lampara "Z" in Barcelona or EI in Yugoslavia. These valves may not be of the quality normally associated with Mullard military production. It's a good idea to check the screen grid feed arrangements carefully. This electrode is usually connected to the tap of a potentiometer across the HT line, and the top resistor often goes high in value.

The Brimar 12AH8 triode heptode was not a commercially successful B9A mixer, but it was used for a few short years before the ECH81/6AJ8 gained market dominance in Europe. The 12AH8 is not pin compatible with the ECH81, although the socket can be rewired to suit the 6.3V Philips type in many applications.

While on the subject of obscure miniature mixer valves, we have the MOV triode hexode types X78 & X79. The X79 was mounted in a sensible B9A envelope but the X78 was crammed into B7G glass, which does not have enough pins to do the job properly. The X78 design doubles one of its heater pins as a connection to the common cathode, which is just plain stupid! Both types make the serious mistake of having the triode section mounted above the hexode section, which causes frequency coverage problems in HF LO applications. The X78 and X78 were little used, and survivors are justifiably rare nowadays.

Many American/Brimar 6K8 circuits have a big electrolytic decoupler on the screen, in parallel with an RF bypass capacitor. These circuits may have a single dropper resistor of value 22kΩ or thereabouts giving typically 100V on the screen grid, with the same DC voltage being fed to the triode anode. Where used, check this dropper component carefully because the screen voltage is critical on the 6K8 and also on the Ediswan Mazda 6C9, which was its B8A miniature equivalent. In addition, the maintenance of good screen grid voltage and decoupling conditions may also be important for correct AGC response, and/or the prevention of motor-boating effects. The 6K8/6C9 used very clever construction, and these valves were very resistant to pulling when the triode section was used as the oscillator. An unusually high impedance 1st IFT primary winding was usually used, to the benefit of both gain and selectivity. The 6K8 was a difficult valve to manufacture and very expensive when new. Being physically and electrically robust, this is one of the more commonly encountered octal types nowadays. The 6C9 was used in far fewer designs, and stocks remain plentiful as this type also proved very reliable in service.

The ECH35, X61M & X81 types of mixer are unusual in that the mixer section is a hexode rather than a heptode. In this respect, these devices are similar to the 6K8, though of more conventional construction. Rather then use an outer suppressor grid, all of these valves rely on an unusually large anode-screen spacing to prevent secondary emission distorting the Vg1/Ia transfer characteristic.

The use of a general purpose triode as a mixer depends on secondary performance parameters that vary greatly between different electrode structure designs. Usually the injection will be at a level of between 3V and 7V RMS for correct performance. The triode may be biased such that the injection lowers the anode current (anode bend operation) or raises it (leaky grid operation). In practice there is little to choose between these two modes of operation, except for the severity of the side effects in the event that the oscillator should ever stop running. Selection of a new specimen of exactly the original type of valve used by the radio manufacturer is definitely the safest way ahead. As an alternative, choose from a boxful of new triodes by various manufacturers, looking at spurious levels and third order intercept point. Certainly this is tedious work. But the on air results are likely to be far better than relying only on selection by valve tester results. With the 6C4/EC90 for instance, there were many different basic types of electrode construction in widespread use. Some 6C4s work well in the R-390. Others do not, despite showing the same or better mutual conductance on a valve tester. In the later R-390A the handbook specifically cautions against the use of type 6C4W, even though JAN type 6C4WA is perfectly acceptable. The writer has a KWM-2A which uses a 6BN8 triode section as the second receiver mixer. The difference in conversion gain between new examples from different manufacturers can be more than 15dB. Analysis shows that the problem is not due to small differences in mutual conductance at low bias. Rather, it is due to big differences in the length of the grid tails. A “good” 6BN8 will shut off with less than 3V of grid bias when 100V of anode potential is applied. A “bad” one will not shut off until >6V has been reached. On the writer’s Taylor model 45C valve tester, the standard test for mutual conductance at a fixed low level of bias does not reveal any hint of the problem. Beware Japanese manufactured Raytheon-branded 6BN8s for use in the KWM-2A! On the other hand, Sylvanias, GEs and RCAs all work fine. The writer also owns a selection of Tier-3 6BN8s branded as Tronix, Zaerix and Bentley Acoustic Corporation. All of these also work correctly in his KWM-2A.

Beam deflection tubes are generally available, but the 7360 in particular commands extremely high prices. There is usually no alternative to replacement by the correct part if the original valve is damaged or (more often) missing. If a good example is fitted, look after it carefully. Japanese and American designs of 7360 differ slightly in their characteristics. Use the right type or organise a swap, in the event of problems.

The 6JH8 and 6ME8 beam deflection valves have an extra grid compared with the 7360 and work rather better as receiver mixers. They are cheaper, too. With all types of beam deflection mixer, the local oscillator injection needs to be at a very high level, perhaps 10V RMS or even more according to design.

Stage gain is proportional to excitation over an extremely wide range. The local oscillator injection may be applied to the deflection plates differentially, or in single-ended mode. Balance of the DC current paths within the valve itself is necessary, and this is invariably achieved by slight differential adjustment of the deflection plate DC voltages. The IF output from the mixer stage may be taken from the anodes differentially, or in single-ended mode.

Beam deflection valves are easily hum modulated by strong magnetic fields so if a μ-metal can was originally specified, make sure it is present and correct. Such cans were often painted red and tended to be heavier than the ordinary types.

The ubiquitous triode-hexode or triode-heptode mixers are best evaluated in the radio. If restoration is underway and all that can be done is to use a valve tester, then the most useful single test is triode mutual conductance. Anything better than 60% of the book value should be regarded as a "pass" result, and probably indicative of adequate installed performance. The real test though, is performance in circuit at both ends of all wavebands looking for whistles and signs of LO dropout.

10.11 Local Oscillators

VFO valves sometimes had a different part number from other valves of the same type used elsewhere in the set. As an example, the 6BA6s used in the VFO of the 75A-4 were allocated Collins part numbers different from the 6BA6s used in the IF strip. This may indicate that these components were pre-aged, had unusually low heater/cathode leakage, or were in some other way selected to be especially suitable for the job. Perhaps they were sourced from a different manufacturer.

If a VFO valve has heater/cathode leakage problems, appreciable filament electron emission, or is a type sensitive to magnetic hum fields radiated from the filament structure or from an adjacent mains transformer, then the effect is usually seen as unwanted AM or FM hum on the oscillator output. The problem is usually worst at the HF end of coverage of the VFO. This may or may not correspond to the HF end of coverage of the radio's RF range, depending on the mixing scheme employed. Because of the multiplicity of causal mechanisms for modulation hum, local oscillator tubes often require selection for lowest residual levels of impressed AM or FM.

Ruggedized valves are very desirable in VFOs, but do try to avoid using brand new ones. It is a good idea to age your chosen valve in the oscillator for 100 hours or thereabouts before final adjustment. The radio will then hold its dial calibration longer.

The slightly different characteristics of valves with the same part number made by various manufacturers, can be useful if there is a selection to choose from.

Where a multi-electrode octal mixer valve from the long list in paragraph 10.9 also operates as the first LO, it may fail to oscillate correctly at the LF end of the highest frequency band. This is where the L:C ratio is least favourable. Under these circumstances, it may be necessary to fit a 6K8 or other type having a higher triode transconductance than the type being replaced.

Try to avoid using an extremely high gain specimen of local oscillator valve. In HF receivers, this precaution will reduce the probability of whistles and other unwanted effects caused by excessive oscillation levels or parasitic oscillation in the VHF region. This phenomenon can cause oscillator inefficiency and/or inexplicably high noise levels in the receiver. As an example of problems that can occur in VHF receivers, the writer has a Hallicrafters S36 which suffers severe LO squegging on Broadcast Band II if an overly good 955 LO valve is fitted. By way of contrast, a weak oscillator valve will cause low drive to the mixer which may lead to insensitivity. Alternatively, the oscillator may drop out or fail to start correctly, somewhere in the coverage range. Weak LO valves also tend to cause seemingly endless frequency drift.

Most LO valves are ordinary triodes, but some strange types have been specified over the years. The Hallicrafters SX28 uses a 6SA7 heptode in its VFO, a type usually used as the mixer. The GEC BRT400 family uses an EL91/6AM5 which is a pentode normally used in audio output stages to deliver about 1W of power. Most radios work best with the specified valve rather than a near equivalent.

Wartime American radios supposed to have a suffix Y valve (6SJ7Y etc) fitted to the local oscillator should have this type correctly in place. The suffix Y indicates the use of a brown coloured low loss phenolic base loaded with woodflour and ground mica. Sometimes a ceramic or micanol base was used with the Y suffix. More usually, the ceramic base was restricted to posh tubes with an X suffix, for example the Hytron 6K8GTX.

10.12 Automatic Frequency Control

In the context of HF receivers, AFC is normally used for SSB/ISB frequency drift compensation, or to maintain frequency accuracy in radiotelex applications.

Reactance valves are used for small frequency changes. These have variable DC voltage drive, and are typically strapped across a local oscillator tuned circuit.

Motorised AFC gives greater variability in terms of frequency range, and was used for the correction of gross system drift in products like the Hoffman CV-157 ISB adaptor for the Collins R-390 or R-390A.

10.13 Calibrators

Calibrator valves are often found to be flat, due to cathode poisoning brought on by lack of use. This situation is not recoverable unless you're lucky with the rejuvenator. Replacement with a fair but used example of the same type of valve is usually the best policy. The use of a brand new valve just for a calibrator is rather hard to justify in these days of rising costs.

10.14 IF Stages

IF strips often use several examples of the same type of valve. The final IF amplifier has to develop the most signal power. It often gets little if any AGC, in order to suppress unwanted modulation rise. Therefore it is a good idea to fit the best specimen you have in this position. A weak valve here may cause an unacceptable amount of distortion on strong AM signals.

A curious feature of 6BA6s and 6SG7s is how frequently they are found to be very flat indeed, even though the radio itself may have been working fine with them fitted; AGC tends to mask the problem.

Some of the more popular types of IF valve are very prone to developing control grid emission. This applies to valves with unusually close spacing between the cathode and control grid, especially those types dating from the days before the need for Gold-plated or Molybdenum grid wires was properly appreciated, or where the valve was cheaply manufactured using inferior grid wire. The problems are most acute when the radio is used mobile with a high battery voltage. The 6AB7, 6SG7, 7H7 and 6AZ8 seem to be the most frequent offenders. Grid emission can cause serious problems in AGC systems, due to the high-value grid feed resistances usually used. Apart from trying another specimen of valve to diagnose the problem, it may be worth raising the mains tap setting by 10V to reduce the cathode temperatures slightly. Another technique which is applicable where a high-value AGC series resistor is used, is to measure the control grid voltage with respect to the AGC line voltage using a VTVM. If more than 100mV higher, the valve may well be developing grid emission and pumping-up the AGC line. The diagnosis is most easily confirmed by substituting a known good valve.

Owners of RCA AR88s, Hallicrafters SX62s and Collins KWM-2s certainly need to be aware of this issue. These receivers have unjustified reputations for poor AGC performance when as often as not, the problem is due to either leaky AGC decouplers or RF/IF amplifier valves which are developing grid emission. As a rider to this comment, the writer will add that the valves fitted to these receivers when new were made by first class manufacturers of the calibre of RCA. Looking at the valves fitted to these old receivers nowadays, many will have been made by tier-2 or tier-3 manufacturers who would not have used the expensive metals needed to properly suppress grid emission.

Gassy IF valves are less commonly encountered, but of course this problem also causes poor AGC action. The effect of the gas current is to jack up the AGC system so that it becomes impossible to develop sufficient AGC PD either generally, or in only one specific stage depending on the design. Given that many AGC-controlled stages have grid series resistors of 2MΩ or even higher, it is obvious that gas currents as low as 500nA can cause serious malfunction. The problem is most commonly encountered when a previous owner has taken a well-thrashed old valve out of his mobile Tx exciter, and swapped it for a good one taken from your receiver.

The suppressor grids of IF valves are usually either grounded, or internally connected to the cathodes. One variation is where one of the suppressor grids is deliberately used as a diode on the AGC line, connected in a way that allows it to provide voltage delay from the IF cathode. The delay may be only a couple of volts, but even that can make a big difference to the SNR recovered from marginal signals.

10.15 Detectors & AGC

Multisection valves need a bit of care when an amplifier triode or, much worse, an output pentode is combined with one or more signal diodes. Gas problems (see output valves section) can cause serious malfunction of the detector or AGC rectifier if the power amplifier valve in the same envelope has been thrashed, or was poorly degassed at the factory. Beware cheap valves…

Where the detector diode is in the same envelope as an audio triode, there may be a problem due to play-through at the minimum setting of the volume control. This is often due to internal capacitive coupling within the valve, in which case it may perhaps be reduced by fitment of a different specimen. Diode-pentodes are much better in this respect, where the pentode was used as an IF section.

Be careful of the Mullard EBC33. This type is very prone to problems with its diodes. Inter-diode shorts are known, as are anode-to-cathode shorts. The problem seems not to be found on EBC33s from other manufacturers. For instance, the wartime military black metallized VR55/EBC33 from Rogers in Canada seems almost indestructible.

Paired diodes which are used as FM demodulators should be specifically selected for good balance. The EABC80 type is often found to have two (out of its total of three) weak diodes after long service, causing suspicions about the VHF IF alignment. Replacement of the EABC80 with a new or known good specimen is often a good idea before spending too long trying to realign the IF strip or ratio detector.

Envelope and product detector valves may need to have low heater/cathode leakage to avoid hum problems. This is particularly true in the case of receivers with series-connected heater chains. Some posh radios put a DC bias on the heater line to the detector (and the noise limiter) to reduce the hum level.

Some pre-war battery sets used indirectly heated double-diodes such as types 2D2 or 220DD. These are now believed completely unobtainable. The best answer in event of problems may be to use a semiconductor diode or two, leaving the original valve in position for the sake of appearances.

Product detectors based on the 7360 valve may be susceptible to hum introduced by the stray magnetic field from the mains transformer.

In some cases, μ-metal cans were fitted to the detector and/or noise limiter. These were often painted red for easy identification. These cans are heavier than the usual type and have the necessary soft magnetic characteristic.

Sets using delayed AGC may suffer from "differential distortion" of the audio as the AGC diode drops into and out of conduction on a weak signal subject to fading. Quite a lot was made of this phenomenon years ago, and some very clever circuits were devised to compensate for the problem as well as one special valve:

the EAB1. The cleverest approach was to provide a level of forward bias for the detector diode which was proportional to the strength of the received signal. In the opinion of this writer these complicated circuits are of esoteric interest only, since most detectors work perfectly well enough for communications purposes when correctly restored to original specification.

Radios having double AGC systems obviously have about twice as much AGC generation hardware to restore as the usual variety. There are no special pitfalls to avoid during restoration. The Hallicrafters SX28 Super Skyrider has a complicated dual AGC system, operating at different bandwidths. Despite the grand claims in the promotional material relating to this receiver, there seems little practical benefit to the user. Each AGC system works so well that the writer's example works fine with only one (either will do!) AGC loop being connected - a useful test of performance. The SX28 does suffer some modulation rise in the final IF amplifier, but that is not really the fault of the AGC system.

The infinite impedance detector is a rarity. It uses a triode biased almost to cut-off. This design has something of a bad press as regards distortion. In reality, this type of detector is perfectly suitable for use in a CW communications receiver. It gives extra selectivity for free and works particularly well if the high value cathode resistor is decoupled to IF only, and not also to AF. This gives lower ultimate detector gain than could be obtained by totally effective decoupling, but the distortion at high levels of modulation is vastly reduced. The McMurdo DST100 has a particularly well engineered infinite impedance detector based on the 6J5G, which is used on all but the widest IF setting. This circuit design gives excellent results on CW and is even passable on SSB.

Anode bend detectors have some similarities to the infinite impedance type, but are rather more common. The GEC BRT400 family uses an EF91 as its AGC detector in a rather complicated circuit which has its own negative HT rail, produced from a dedicated rectifier/reservoir arrangement. The overall result is excellent. This set can generate such large amounts of AGC for its W81 (later variants used 6BA6) RF and IF valves, that it can accommodate 100dB of input signal range without overload.

10.16 Magic Eyes

The main design problem with magic eyes is the loading they put on the signal detector in the many circuits where the magic eye is fed from this stage to avoid the effect of AGC voltage delay. Little can be done about the resulting AM distortion, except to use a large grid series resistor (in comparison with the diode load), together with a low leakage decoupling capacitor on the control grid of the eye amplifier triode section. To avoid the AC loading problem, some of the more expensive sets used an entirely separate detector to feed the magic eye without any voltage delay. Some of these radios put the main magic eye on the signal detector to help tuning on weak signals and had a second, reduced sensitivity, magic eye running on AGC for use on strong signals.

Special mention needs to be made of the pre-war Philips magic eye type EFM1, which was a combined AF pentode and magic eye used in posh sets like their 735A. The EFM1 was also made by Tungsram, and by French manufacturers. The EFM1 was also made on the German octal base as type EFM11, which nowadays is even rarer than the EFM1. As an exercise in "reverse engineering", Telefunken mounted its own EFM11 bulb onto the CT8 base for the Italian market. This created valve type WE18, which is fully interchangeable with the EFM1. The pentode section of the EFM1 needed to be connected to the signal detector for DC as well as AC purposes, which meant it automatically introduced feed-forward AGC. This in turn, meant that the audio amplifier needed heavy feedback to reduce curvature distortion to acceptable levels. Some good news with the EFM1 is that there were at least no problems with AC loading of the signal detector caused by the magic eye section. Nowadays, the main problem with type EFM1 is one of finding supplies. Though produced by Philips in large numbers, this type is now rare and correspondingly expensive. One perfectly good reason for this scarcity is the lack of light output resulting from heavy inking inside the viewing end of the valve, at least on early production examples. Frequent replacement would have been necessary. Post-war EFM1 production had an ordinary clear viewing window, and these later devices are a lot brighter. In the event of non-availability, the best approach might be to change the socket to suit an ordinary octal magic eye such as the 6U5G, and then mount a wire-ended variable-μ pentode such as a 5899 or EF731 directly on the socket tags. Alternatively, it should be possible to rewire the base to suit an EF9, and do away with the magic eye functionality altogether.

To obtain the correct shadow pattern at zero signal input, the cathode of the magic eye was often tied slightly above chassis potential, typically to a point part of the way up the cathode string feeding the receiver audio amplifier or output stage. In the event that an incorrect shadow pattern is found, it is a good plan to look at this area of circuitry first, and only then move onto the anode and grid supplies.

The main restoration problem with magic eyes of all types, is lack of light output. This has led to a distinct shortage of certain types due to the need for frequent replacement in the past, combined with modern-day collectability. The problem is caused by phosphor burnout rather than lack of cathode emission. This is shown by the fact that many weak magic eyes still glow brightly from the part of the phosphor that is only illuminated under extraordinarily high levels of input signal. Many older magic eyes took a lot of target current - for example the Mullard type TV4, and sometimes the current drain was very variable between samples. This can lead to significant differences in light output even between new and unused valves of the same type.

One clever receiver once owned by this writer was made by the Swiss manufacturer Paillard, being their model 59. This only energised the target electrode of its UX6-based 6E5 magic eye with the full HT voltage when the maximum selectivity position of the IF strip was selected. In the other positions, the valve received rather less than 200V and glowed only dimly. The original magic eye had remained in service for 57 years, and was still in very good condition. This intelligent piece of design has not been seen on any other receiver known to this writer.

Some magic eyes were available with either fixed-mu or variable-µ triode sections, examples of the latter being much harder to find nowadays. The fixed-mu types such as EM81 & UM81, were usually found in measuring instruments such as RCL bridges and GDOs. The variable-µ types such as EM80 & UM80 were usually found in radio receivers. There is currently a despicable trade in re-marking ordinary EM81s and the Russian 6E1П valves as EM80s, and re-marking UM81s as UM80s by carefully scraping off the original chalk Mullard markings. These practices are deliberate attempts to catch the unwary, or to lighten the wallets of those who cannot recognise inappropriate behaviour of the shadow pattern in their radio. You are cordially invited to mount one of these impostor magic eyes on a valve tester. Its shadow will close at less than 6V of grid bias. This amount of grid swing is not nearly enough to allow the eye to indicate the full range of AGC voltage on the average receiver. A genuine EM80/UM80 does not close its shadow at less than 15V of grid bias.

Some side-viewing magic eyes have the type number stamped directly in front of the target. This is a clear manufacturing error, yet this fault is seen surprisingly frequently.

Much confusion surrounds tubular octal types EM34 and 6AF7. Both are European magic eyes of dual sensitivity, the EM34 being directly equivalent to American type 6CD7. The 6AF7 is a French type. Note that despite its number, this is not an American valve. The military CV394 is supposed to be equivalent to commercial type EM34. Now consider this: the writer has three new & boxed Amperex (a USA brand owned by Philips) valves which are actually type 6AF7 even though they are marked EM34/6CD7. The Soviet bloc never seems to have made copies of the genuine EM34. The differences can be summarised as follows:

EM34: constant diameter over both bulb and bakelite base; 200mA heater.

6AF7: bakelite base of larger diameter than the bulb; 300mA heater; electrode structure may be (but not always!) offset by 15° compared with the EM34.

How much these differences mean in your radio may depend on whether the heaters are wired in series or parallel, and whether provision exists for rotating the magic eye relative to the cabinet. Some sets that were designed for a genuine EM34 cannot mount a 6AF7 due to the oversize bakelite base.

Further confusion exists surrounding tubular octal types 6U5G (not 6U5GT - no such type exists) and EM35. The genuine Telefunken EM35 has a Maltese Cross shadow pattern of dual sensitivity, and this device was badge-engineered as type 6M2 by Ediswan Mazda. In contrast, the 6U5G is a very ordinary American magic eye of single sensitivity, also available as type Y63/VI103 in a shouldered glass envelope. In the UK, type 6U5G was made by Brimar who erroneously listed the EM35 as a direct equivalent to it in their early data books, and even made many valves marked "6U5G/EM35". The trade has seized on this error with glee! The result is that nowadays, several dealers routinely pass off ordinary 6U5Gs as EM35s, even though these two types are not functionally interchangeable. In contrast, the genuine EM35 is fully replaceable by type EM34. The only difference is the layout of the shadow pattern. So this swap can be made easily, safely and without loss of functionality.

10.17 Noise Limiters

Noise limiters are very often troublesome. Most benefit from selection of the limiter valve for minimum hum. Exceptions include the Collins 75A-4 and late-production RCA AR88D radios which operate the noise limiter valve under current-starved heater conditions, and the Eddystones S880/2, EA12 and 830-7 which apply a few volts of positive bias to the centre tap of a dedicated heater supply rail.

One problem with the Eddystone approach is that because the limiter has a dedicated filament winding, it gets full voltage at the moment of applying mains power. This can cause the cold double-diode filament to flash brightly, with the result that open circuit filaments are commonly found in Eddystone noise limiter stages. One answer is to fit a posh EAA901S which has very low hum, a non-flash heater and which will not suffer cathode poisoning… but this is an expensive little valve!

One way of current-starving the filament of the limiter to reduce hum in an early or mid-production RCA AR88D, is to fit a 12H6 in place of the original 6H6. This is much easier than going underneath and adding the series resistor network, if the necessary valve is readily to hand. Takes ages to warm up, though!

Many 1950s and 1960s sets use either a (physically tall) EB91/6D2/D77/CV140 or a (physically short) 6AL5/EAA91/E91AA/5726 in the limiter stage. The only difference between these two families is the amount of vacuum above the electrode structure inside the glass; the actual electrode structures are identical. Because the limiter diode is not normally conducting while its heater is powered, these valves commonly suffer from cathode poisoning. The problem is seen as a mysterious lack of limiting effectiveness when noise pulses are present. The best valve for the job is the rare and expensive EAA901S, which was made by Philips and Telefunken as their poshest 6AL5 type. By special design and use of advanced materials, the EAA901S is completely immune from cathode poisoning even after thousands of hours service in a noise limiter circuit. The low-height military and industrial types 6AL5W, M8212, 5726, E91AA & CV4007 were designed to live long lives under conditions of shock and vibration but they were **not** specifically designed to resist cathode poisoning, and are therefore not equal to the EAA901S. Physically robust military versions of the tall EB91 included types CV4025 and M8079. Neither of these was designed to resist cathode poisoning, either.

Separating sheep from goats can be difficult sometimes. Towards the end, Brimar were sometimes sloppy about their valve markings. One result was that this company produced valves marked 6AL5 in the larger EB91 envelope size. As may be expected, counterfeit EAA901Ss certainly exist so care is needed when buying this type.

There never were any unpoisonable versions of the 6H6/EB34/D63 family. If the noise limiter seems ineffective, the best that can be done is to try a brand new valve. Fortunately, all of these octal types remain plentiful and cheap at the time of writing.

10.18 Audio Stages

Audio output valves run hot in normal operation. They get even hotter if the grid coupling capacitor goes a bit leaky! To check a grid coupling capacitor, briefly short the anode of the audio driver valve to earth with a screwdriver, whilst measuring the cathode voltage of the final stage. There should be no change in reading greater than 100mV. This test only applies to output valves having automatic bias.

In mains-powered communications receivers, the usual output stage comprises one or two pentodes or beam tetrodes. Very often the two types are more or less interchangeable, for example 6K6/6V6 in different models of the RCA AR88, and the 6F6/KT63 in the Marconi B28. Some popular output valve types have been constructed as both pentodes and beam tetrodes over the years, the EL95 and EL34 being examples. In the case of beam tetrodes, the suppressor grid G3 is usually either brought out to a dedicated pin, or connected internally to the cathode. But variations do exist. Some American manufacturers sold types 42E and 6F6EG pentodes which were identical to the standard products except for having G3 internally connected to G1 rather than the cathode. A type 42E can often be used where a 42 is specified (for example a 42E works fine in the HRO-MX), but there may be some applications where a 42E would oscillate due to its much higher feedback capacitance from anode to control grid. If planning to use one of these suffix-E output valves, a good look round with an oscilloscope would seem a sensible precaution.

Gas problems are cumulative, and must never be ignored. Excessive heat causes gas that was previously trapped in the anode & screen grid metalwork to be released into the vacuum inside the valve. Too much vibration causes damage to the insulating micas, which then release the gas trapped in their structure. All of this gas then ionises with a positive charge and the gas ions wander towards the most negative electrode, which is the control grid - pulled there by electrostatic attraction. On collision, this causes grid current to flow. If the grid leak is much over 470kΩ, the negative grid bias can reduce appreciably because of this ion bombardment. The anode current then rises, so that even more heat is generated in the anode and screen grid. This process can happen cumulatively during the first few minutes of operation, causing a steadily rising HT current. Even more gas then gets liberated. The valve soon goes “soft”. The situation escalates until the HT fuse, valve, output transformer, HT choke, rectifier or mains transformer fails. Some of the gas ions may collide with the cathode instead. If severe, this can lead to the mechanical fragmentation of the oxide coating.

The vicious spiral can appear in American sets with fixed grid bias lines, but seems at its worst in British sets using high gain output stages operating with low bias voltages. The problem is notably common in radios using the high gain UL41, see below.

Certain types of output valve are now widely recognised as being unreliable. The ECL83 and 6AK6 are prone to inter-electrode shorts. The valves most vulnerable to gas & grid emission problems are the E/UL41, E/P/UL84, N78/CV3711, E/P/UCL83 and EL22/CV304, whereas the E/PL95 and EL90/6AQ5 are inclined to go very flat. Just for good measure, the E/UL41 types are inclined to develop internal G1-G2 leakage paths and HK shorts as well! On top of all these problems, the high heater voltage of type UL41 can cause 50/60Hz audio hum in the event of even tiny leakage between pin 6 and pins 1 or 8 as the valve ages. There are big variations from manufacturer to manufacturer for the same type of valve, depending on the quality of materials used, and the efficiency with which degassing and gettering operations were performed at the time of construction.

A good telltale for grossly excessive current in the output stage is an HT regulator neon that doesn't glow, because there is insufficient HT inside the radio to strike it.

A “soft” valve is one suffering from gas ionisation, shown as a pale mauve/pink glow inside the anode structure. It must not be confused with fluorescence, which is a sign of unusually good vacuum. This is seen as a dark blue glow just inside the glass wall of the envelope, well outside the anode structure. Sometimes the inside of the glass is carbonized (sprayed with graphite or ink) to stop this secondary emission from the bulb - or at least, prevent it from being visible! GEC Osram, RCA and Brimar were very inclined to use a graphite coating. Mullard and Ediswan Mazda less so. The graphite coating was primarily there to lower the anode temperature by increasing radiation from the valve envelope.

Push-pull audio was used by Hallicrafters and Eddystone, amongst others. The valves are best chosen from the same manufacturing batch, but there's no need for perfect matching in a communications receiver. Genuine push-pull arrangements give far less trouble than self-feeding paraphase circuits. With all designs, be sure to check with an oscilloscope that the grid and anode AC voltages are equal, and anti-phase to within 10%.

The DC voltage drop across each half of the output transformer primary should be within 10% at no signal. Because of the way it is constructed, the DC resistances of each winding will often not be identical even though they have exactly the same number of turns; so it's no good expecting perfectly equal DC voltage drops.

Check that in actual service, both output valves get equally hot and if not, investigate. One of the valves may be flat, or oscillating at VHF. Be particularly suspicious of any cracking noises or scratchy distortion from the loudspeaker, sounding for all the world as if the speaker voice coil is rubbing on the pole piece. This is often an audible symptom of unwanted RF oscillation in the output stage.

One problem unique to push-pull audio output, and the reason this writer dislikes its use in communications receivers, is the variation in HT current with signal at medium and high volume levels that occurs unless the stage is operated in true class A mode. As the valves start to draw extra current on peaks, the HT voltage then becomes modulated by the bass content of the audio. On the higher RF frequencies particularly, this can cause the local oscillator to suffer pulling or fluttering problems. This is especially true if no neon regulator is fitted, and when listening to SSB transmissions. Bias problems can cause HT current variations greater than intended, so a careful check of grid and cathode voltages is an essential early step in the overhaul of any push-pull output stage.

Battery sets often had intricate QPP or class-B output stages. The QPP type used a pair of pentodes biased almost to cut-off, with grid excitation usually coming from a step-up voltage transformer. In contrast, true class-B designs used a pair of zero-bias triodes which were driven into conduction by feeding their grids from a step-down voltage transformer capable of providing significant AC drive current on speech peaks. Both of these types of output stage are very prone to balance problems, a common symptom being gritty and distorted audio.

The testing of battery output valves is generally straightforward except in the case of class B valves, whose only satisfactory examination is by measuring the audio output power and distortion under conditions of representative positive grid current.

Mains output valves of all types should ideally be tested for grid current when they are thoroughly hot, to avoid misleading results due to grid emission or gas accumulation. If the radio uses automatic bias for its output stage it's often easier just to measure the standing DC voltage on G1 in the radio, using a VTVM.

High slope pentodes are inclined towards BK oscillation, which can set in when the anode voltage drops well below the screen potential. The effect is a highly unstable oscillation at HF or VHF, which is self-sustaining and inclined to raise the anode current well above normal. The valves showing this problem most often are high slope European B7G types N78/N37/N108, and the B9A-based EL84/6BQ5. The usual fix is a 1kΩ grid stopper, maybe with a 10Ω anode stopper - and even a 100Ω screen grid stopper as well, in stubborn cases.

10.19 HT Regulators

Neon regulator tubes are usually trouble free, but not invariably so. Quite often, especially with S130P and 85A2 types, the operating voltage will be found inaccurate by more than 10%. This is believed due to changes in the gas pressure over the years, caused by diffusion through the glass envelope. Yes, the gas will pass through the glass envelope over time even if the seals are perfect! Of course there may also be leakage through the base seals due to manufacturing errors. If the operating voltage is significantly wrong, there is no alternative to replacement of the valve. Fortunately, most types of neon are still cheap and plentiful.

AF oscillation of the regulated line is sometimes seen, typically causing unwanted sidebands on the local oscillator. This is usually caused by excessive capacitive decoupling of the regulated rail. Make sure a previous owner has not strapped an electrolytic across the neon in a misguided attempt to improve performance.

Neons have a certain “memory” which causes the regulation characteristic to change over time, and be partly dependent on recent operational history. There is good sense in running neon regulators for maybe 10h before drawing too many conclusions about the level of performance in your radio.

Some S130P valves of GEC manufacture have an orange glow, rather than the usual mauve. [Pic130] These valves give superb voltage regulation. Unfortunately, the extraordinarily low dynamic resistance of the “orange” types can sometimes cause oscillation of the regulated HT line in a GEC BRT400D when operating at high mains voltages. This is indicative of an overall negative circuit resistance. The oscillation problem has never been seen in the same circuit when working with a healthy “mauve” S130P. The oscillation resulted in a Christmas tree of local oscillator sidebands on the highest range of coverage. This was a wholly unacceptable side effect of a valve type which in other respects was much better than the average. The problem could no doubt have been fixed by the addition of a suitable Zobel network across the neon or by fitting a small series resistor, but either of these options would have needlessly destroyed originality.

Some British neons were available with and without a priming electrode, for example the S130 and S130P. When fitted, the priming electrode took the form of a simple pin, or sometimes a woven wire basket made of a metal having a low work function such as Silver (Ag). [See LHS valve shown in Pic130]

S130s and S130Ps varying between 113V and 153V are held by the writer. The rated regulation voltage is 115V-135V at 75mA, dropping by up to 10V when only 10mA is drawn. In general, GEC shouldered-glass types are near the top end of the voltage range, and Cossor balloon-top types near the bottom. Care is needed to select an S130P sample which gives adequate voltage stability over a reasonable range of mains input voltage. The glow should be wholly contained within the cathode bucket. If it creeps outside because of incorrect gas pressure, the voltage regulation will be poor and the output voltage will rise above 120V. All balloon-top S130s and S130Ps are mechanically fragile, to add to the problems.

The successful operation of a neon voltage regulator depends on the convection of gas inside its glass envelope. Fitting contact-cooled cans where not originally specified, is unwise. Frequently it will be found that the neon was originally supported by a can of fluted, mainly open construction; or maybe no can of any type was fitted. The best advice is to leave everything as originally built.

Russian neons were sometimes very different from western equivalent types. The writer has several Russian 0A2 B7G 150V neons branded National (for Richardson Electronics Ltd), Amperex and Zaerix (for Z&I Aero Services Ltd). These are shorter but heavier than the usual, due to having a very thick glass envelope. The cathode bucket is barrel-shaped rather than plain cylindrical, and its surface has been etched or spark-eroded to increase the effective surface area. No mica is used in the construction of these neons. Instead, the top and bottom edges of the cathode bucket are supported by a pair of ceramic biscuits held inside spring fingers to centre them inside the glass envelope. These neons were obviously expensive to manufacture! Unfortunately the usual Russian sharp pins are used, calling for careful positioning of the valve in its socket before final insertion. Under test, the regulation performance of the Russian 0A2 is about the same as the western types, at least in the absence of mechanical vibration. Some Russian 0D3A octal 150V neons in stock here are branded Brimar and Pinnacle. These have a tall GT envelope and yet the (plain cylindrical) cathode bucket is rather shorter than the usual RCA/Sylvania size. They work well enough right up to 30mA current, just the same.

A specific caution for neon regulators concerns the suffix WA (US military ruggedized) variants of 0A2 and 0B2. These contain a radioactive isotope which was intended to promote ionisation and hence lower the striking voltage. The activity level and half-life of the isotope used, is not known to this writer.

Some valve radios used a Zener HT regulator diode for the VFO. The Racal RA117E and KW2000E are examples. These early devices were unreliable and should be checked carefully. Replacements can be difficult to find as the stud needs to be the anode (negative) pole of the device. A quick catalogue search revealed that a 150V 5W Zener with its anode connected to the stud, is not commercially available nowadays. A 0A2 neon may have to be fitted instead, or a special insulation arrangement made up to use the cathode-to-stud version which is still widely listed.

Neons can be extremely noisy and it is worth trying a 100nF capacitor across the regulated line while checking the purity of the LO at the HF end of its most HF range. This makes a big improvement sometimes, as for example with the KW202. Care is needed because on other radios such as the GEC BRT400D, adding this same capacitor can induce severe oscillation.

High voltage zener diodes can also be extremely noisy and because they are far lower impedance than a neon, much more decoupling capacitance is needed. For example the zener used on the KW2000E needs an extra 22µF to achieve a clean oscillator note.

10.20 Thermionic Rectifiers

Rectifier valves should always be checked for the presence of any bits of white oxide cathode coating floating around loose inside the envelope. Post-war Ediswan Mazdas are especially prone to this fault. It is usually due to a past flashover caused by an HT short or an extraordinary mains transient. Some loose oxide is OK but a lot of it, or a big bald patch on the cathode, would condemn the valve.

Rectifiers can stand a lot of gas before they malfunction, but in extreme cases the valve can flash over from this cause.

Some rectifiers take ages to warm up, especially Mullard type CY1. This is not necessarily indicative of a fault. Thick wall cathode tubing may have been used in manufacture to make sure the rest of the valves in the radio all get a chance to warm up fully before the HT appears.

If the rectifier is a multisection affair like a U801, make sure all of the heaters warm up, and that all of the individual internal cathode and anode connecting straps are intact where they go to the lead-out wires on the pinch. Each section of one of these valves would typically have its own small current-equalising resistor in series with the connecting pin. These all need to be present & correct to avoid hurting the valve.

One fact about rectifiers that puzzles this writer is the great difference in HT voltage developed by different samples of the same type. Some radios such as the Hallicrafters S36, are generally short of HT and would benefit from a more efficient rectifier. Others like the Eddystone S940C produce excessive transformer secondary voltages and are at their best with a low output rectifier. In the case of all these radios, special care to select an appropriate rectifier is a very good idea.

Some rectifiers proved unreliable in service. Your attention is drawn to American type 26Z5W which was used in the Collins R-390/R-390A family of receivers. The problem was exacerbated by the fact that not all of these complex receivers had an HT fuse. In the Collins R-390, the fully regulated HT system ensures the 26Z5Ws are really thrashed even when no faults exist. The octal 6X5GT/EZ35 and B7G 6X4/EZ90 had a 450V heater-cathode rating which allowed their 6.3V heaters to be paralleled with all the other valves. Even so, insulation failure was not uncommon. If your radio was not originally fitted with an HT fuse, it may be wise to consider a modification to fit one at this stage. It should be a quick-blow type rated at about three times the normal running current.

Do not be tempted to use a directly heated rectifier where not originally specified. The cold start over-voltage problems are as for Silicon rectifiers, though less severe. The higher losses of direct rectifiers compared with indirect types can cause insufficient running voltage, oscillators to cease functioning, and neons to go out as the set warms up. Similarly, do not be tempted to use an indirectly heated rectifier where not originally specified. The main problems here concern a tendency towards hot restart flashovers, excessive running voltages, and audio hum caused by insufficient HT series resistance.

10.21 Transistor Stages

In the context of valve radios, transistors are found in the final generation and performed mostly secondary functions such as heater voltage regulation, meter driving and low level audio amplification. Most are Germanium PNP types from the 0Cxx, 2Gxxx and NKTxxx families. On American equipment, early Silicon NPN types from the 2Sxxx and 2Nxxx series will usually be encountered.

Silicon devices have stood the test of time well but Germanium types have not. Modern hazards include intermittency developed as a result of Gold migration on the surface of the chip (the "purple plague"), noisiness (usually with pronounced leakiness as well) due to inadequately clean conditions during manufacture, and short circuits developing between the electrode structure and the outer casing. In particular, members of the Mullard 0C17x, AF10x and AF11x series of PNP RF/IF Germanium alloy transistor nowadays often suffer from low gain and/or shorts from electrodes to case. They are best replaced by types from the AF12x series which are basically the same chip in a modern TO18 package. If in doubt, use an AF127 but beware its unusual BECS pinout, reading clockwise from the tab while viewing directly onto the wires. Some manufacturers issued this type with the more normal EBCS configuration so great care is needed, and every device must be tested before use. The Texas 2G417 can also replace the AF117 etc.

The writer has recently (2010) binned a large bag of Mullard AC128 PNP audio output transistors because of shorts between the collector and case. This problem will no doubt be due to the same Tin whiskering phenomenon that affects the AF117 etc, and is very worrying for the future of our hobby.

With the 0Cxy family of Mullard small signal transistors mounted in little shut-ended black painted glass tubes, the devices can become photosensitive if the paint film is damaged. This is especially true of early manufacture, when a clear jelly was used inside the device instead of the opaque white stuff that was used later on. This can cause puzzling hum or buzz when the radio is out of the cabinet on the bench, illuminated by a bright fluorescent inspection lamp. The 0Cxy family is reliable, which is good news.

Most early devices are still available very cheaply in 2011. For low level audio applications, you may need to try a selection to get an acceptable noise level. Unlike valves, just because these early semiconductors have not been used does not stop long term problems from developing. Remember to use a heat shunt when soldering Germanium devices, because these things are thermally fragile.

If an alternative type has to be selected to replace an unobtainable original device, it is a good idea to use a Germanium type to replace a Germanium original, and likewise to always replace Silicon with Silicon. Otherwise re-biasing will be needed to reflect the differing Vbe voltages, which are approximately 200mV and 600mV respectively.

When rebuilding heatsink assemblies, it is important to replicate the original arrangements as closely as possible and in particular, to ensure the correct seating of all metal pieceparts. Heatsink grease should be used when necessary, remembering not to over-tighten the transistor securing screws. Excess force can buckle the base plate of the device which causes lack of thermal contact right under the chip, which is exactly where it is most needed.

Transistor cooling arrangements sometimes use heat-conducting washers that are electrically insulating. A popular material for this job was Beryllium Oxide, which is very hard indeed. It is white with a slight pink or blue tinge, and its dust is toxic. For this reason, special safety precautions should be adhered to with regard to handling, storage and disposal. Alternative materials that might be found include Aluminium Oxide (alumina) and Boron Nitride. Neither of these is particularly hazardous. Both are dead white in colour, and thermally inferior to Beryllium Oxide.

11. Other Components

11.1 Wire-ended Component Replacement: General

Starting a restoration project by changing all the resistors & capacitors right at the beginning of the job, is often a recipe for disaster. The writer strongly recommends starting with conventional fault-finding and localised component replacement, to end up with a radio that is basically working properly. Only then consider changing groups of components one circuit block at a time, with comprehensive functional testing before moving on to the next PCB or whatever. This approach minimises the chance of introducing multiple new faults, and reduces to a minimum the amount of work needed to completely finish the job. Otherwise there is every chance of ending up with a radio that performs almost correctly, but with several puzzling residual faults. If the radio doesn't work properly, it's a good idea to identify that fact as soon as possible in the repair sequence. Start by checking your own work. This writer has spent hours chasing faults that he himself put there by accident - try to avoid doing the same thing!

Use HMP alloy solder to connect the wires and lugs of hot running dissipative components like wirewound resistors and heater thermistors. The iron should be a medium/large type with a tip temperature of +450ºC or thereabouts. Use LMP alloy solder to attach the lead-out wires of all other components to their termination solder tags, using a medium/small iron running at about +350ºC. This will avoid excessive reflowing of the original solder.

It may be possible to locate a source of new components with Copper lead-out wires rather than the usual (nowadays) steel. This would make the job of repair very much easier, as Copper is much more ductile.

Most radios were originally constructed with each joint being wrapped before soldering. However some receivers, especially Eddystones, used laid-on joints that were not wrapped. They seem none the worse for it. [Pic055] This really does open up the question of whether it is worth the bother of unwrapping and rewrapping the solder joints during repair of all other makes.

Wick seems to work better than a plunger sucker for removing old solder, but there is great variability in the quality of the wicks on offer. Don't keep too much in stock for long periods, as this stuff loses efficiency quickly when the braid starts to oxidise. The writer uses Chemtronics Soder (sic) Wick Rosin SD, size 5, their reference 80-5-5 which works extremely well and is a good size for old radios.

Wires from glass-encapsulated devices such as some valves, bead thermistors, crystals and diodes should not be bent within 1.5mm of the envelope, or soldered within 5mm of it.

11.2 Resistors

Check in particular, the values of all cathode & screen resistors, and all carbon HT dropper resistors. If more than 20% away from the nominal value, replace the component. Where sufficient space exists it is worth thinking about uprating the resistor, to stop the problem happening again in the future. Having said this, many of the better quality radios have low wattage series resistors fitted in the HT feed to each stage, typically 2.2kΩ/¼W. These all need to be checked carefully. If darkened, burned out, or incorrect in value, first find out why. Then replace the component with the same value <u>and wattage</u> as originally. These resistors are intended to act as telltale fuses to identify problems downstream in the circuit diagram. They will not do this job properly if you uprate their power dissipation capability.

On radios that have seen little use, carbon resistors may have drifted higher or lower than their original values. But on sets that have run lots of hours, the rule seems to be that they all drift upwards. It is depressingly common to examine a 1960s radio that looks in good condition, only to find that half the resistors have gone 20% high, with some now double their original value. The grey Dubilier resistors fitted to hot-running Eddystones seem to be the worst offenders.

Do not be tempted to bridge resistors that have drifted high, to try to restore the original value. Experience says that drifted resistors will continue to drift, so the new combination could not be relied on to stay within tolerance.

Similarly, open circuit resistors cannot be relied upon to stay open circuit over future years. So always clip them out of circuit. A special caution is needed with American metal clad “Candohm” wirewound resistors. These things cannot be relied upon either to stay open circuit from end to end, or to remain insulated from chassis once the element has broken and fried the impregnated cardboard insulation somewhere inside the component.

It’s wise to replace all wirewound resistors that have cracked or missing insulation, even if they measure OK at the time of overhaul.

Sometimes an unfamiliar radio comes in, with a big power resistor that has gone open circuit. If you don’t know the original value, you can try chopping the resistor in half. One side usually contains the open circuit, and the other side is okay. Then measure the resistance of the “good” half, and double it to identify the correct resistor value.

The writer is always cautious of potential divider arrangements providing negative grid bias on American sets, or positive bias to the top grid of double-triode cascode stages on British ones. In these circuits, resistor problems are very much the rule rather than the exception.

Dubilier grey or brown power resistors with fibrous bodies should be condemned on sight. [Pic056] These components are extremely prone to going high in value, and they can get very noisy in old age.

A quick check for noisy resistors is to squeeze them gently with pliers. This will often dramatically change their noise output.

11.3 Non-electrolytic Capacitors

Paper HT smoothing capacitors in grey-painted metal cases with ceramic pillar terminals had a period of vogue in the days before electrolytics became fully trustworthy. In general, if such capacitors look undamaged and are not weeping oil, they are probably perfectly serviceable and not worthy of special investigation. If replacement is needed, it will be in order to use modern electrolytics of suitable ripple current rating except in the case of vibrator power supplies, where plastic film dielectric devices should be used because of the square waveform of the ripple current.

This writer recommends the routine replacement of all inter-stage coupling, screen grid, noise limiter and AGC tubular capacitors.

In HT and screen feed systems, waxed paper/cardboard tubular capacitors that ooze wax or which have obviously done this at some time in the past, must certainly be replaced. In these cases, the physical leakage of sealant is due to overheating caused by progressive insulation failure. The problem seems to be cumulative, and is often accompanied by a rise in value of the associated HT feed resistor.

A different version of the same problem is often seen with lozenge shaped encased mica capacitors. [Pic057] Sometimes these ooze a kind of sticky froth from where the lead-out wires leave the case. This is evidence of chemical activity going on inside, again due to insulation breakdown. On any particular chassis, this problem always seems worse on capacitors with DC voltages across them than on ones without. The El Menco red micas often seem problematic. They tend to go leaky and lower the Q of the circuits they are in, causing oscillators not to start and other bothers. The older Collins radios usually have plenty of El Mencos to go wrong - and they do! In contrast, Centralab capacitors which look very similar are usually trouble free.

Not all lozenge-shaped capacitors found in American equipment turn out to be micas. The RCA AR88D coilbox has several paper capacitors with a very similar style of moulded case, usually pink in colour. These things are if anything even less reliable than El Menco micas, and should certainly be changed.

An alternative type of problem is often seen with silvered mica capacitors made by Lemco. The ones coated in red cement are sometimes found open circuit. The Racal RA17/117 filter blocks are full of these capacitors (value 43pF), and an open circuit red Lemco can cause a serious performance defects. This problem seems not to occur with green cement-coated Lemcos, or with the later pale blue ones that are coated in silicone rubber.

Polystyrene capacitors sometimes go open circuit where the leadout wire enters the plastic casing. This problem is most commonly seen on Sufflex or SEI types, but the writer has seen the same fault with Wima polystyrenes on occasion.

It is a good plan to check that the AGC circuit resistance exceeds 100MΩ when all shunt resistors are disconnected, but with all of the AGC capacitors left in circuit. This is a good opportunity to measure each of the shunt resistors individually, while they are temporarily disconnected from the rest of the circuit.

The grid coupling capacitor(s) to the output stage must be absolutely beyond reproach. This is so important that the writer feels the need to say this again: **The grid coupling capacitor(s) to the output stage must be absolutely beyond reproach.** Otherwise, extensive long term damage may be caused to the output valve(s), rectifier(s), output transformer, HT smoothing choke(s) and/or mains transformer. The writer trusts good quality original ceramic capacitors in this application, but replaces all other types as a matter of routine. Tubular polyester capacitors of 400V minimum rating are generally satisfactory as replacements. Capacitors rated at 600V are even better.

On British radios, change on sight all brown or black Hunts moulded tubular capacitors, and all bitumen GEC & Philips paper capacitors. [Pic058] All of these types are prone to crack their insulation casings and go very leaky indeed or alternatively, open circuit.

On American radios, change on sight all Sprague black tubular paper capacitors that have colour coded rings, because this type frequently crack their casings and go very leaky. [Pic060] Hammarlund SP600s are full of them, and they are also to be found in the Collins R-390A.

On European radios, the brown Wima and Rifa dipped wound film capacitors are nowadays troublesome, and should be replaced.

A quick check if you are suspicious that a tubular capacitor is intermittent, is to squeeze the body of the component gently with insulated pliers. This can often introduce the fault decisively and sometimes permanently. So be prepared to switch off quickly!

Bathtub capacitors are frequently encountered in American radios. [Pic059] These give neither more nor less trouble than the average equivalent wire-ended components. Any goo oozing out around the terminal seals indicates the need for replacement. For an invisible repair, the casing may be unsoldered with a blowlamp. Do this job outside in the fresh air, standing upwind of the component. Drill some small holes in the rear plate first, to avoid risk of explosion due to pressure build-up. After gutting the interior and cleaning the case inside and out, you can fit new epoxy-cased radial wire-ended capacitors inside. Solder one lead from each component to the inside of the metal case. Use grommets with metal spacers inside, and solder tags at each end of each spacer, to replace the original sealed insulated terminals. No not bother to refit the rear plate because it is no longer needed for its original purpose, and in any case it would be invisible when the capacitor is refitted to the radio chassis. Your attention is drawn to the fumes given off during the repair process. The original liquid content may be a PCB type and should therefore be regarded as hazardous to health.

If you are concerned to preserve the original appearance of the underside of your chassis apron, it may be possible to fit modern tubular polyester capacitors inside the shell of old wax- and metal-cased tubular paper originals. The writer has never done this type of cosmetic surgery, though it is certainly popular nowadays.

11.4 Electrolytic Capacitors

This writer recommends that you change all electrolytic capacitors more than 25 years old. Be especially diligent with red, yellow & black plastic-cased wire-ended Plessey types, anything made by Callins, and all others that show signs of bulging or cracking of the rubber endcap or where there are signs of electrolyte leakage. [Pic061] Any reservoir capacitor showing signs of arcing around the terminal rivets must also be condemned.

American military radios were inclined to use octal plug-in reservoir and smoothing capacitors. These components are usually of excellent quality, and need not routinely be replaced. The only problems associated with these things occurs when the base or socket contacts get a bit tarnished, or when the tag-securing rivets work lose. These faults can cause mysterious hum and/or low rectified HT voltage.

The Mallory FP series of twist-tag electrolytics was used in many of the American commercial radios. This type has also proved to be very reliable. Most problems are due to high-impedance earths at the twisted base tags, sometimes with signs of arcing. In the UK, the Mallory range was licence manufactured by Plessey who fitted an orange plastic skin over the whole assembly. These capacitors have proved less reliable than the American originals. In particular, the incidence of high impedance earth paths is higher due to the plastic skin shrinking away from the grounding points which causes looseness of the earth tags.

It’s unwise to increase the capacitance of the HT reservoir. This could strip the rectifier cathode of its oxide coating during a hot restart. Especially if it’s an Ediswan Mazda rectifier from the 1940s or 1950s In addition, the reduced conduction angle will cause increased Copper loss in the transformer windings, making this component run hotter than originally.

Avoid using a cheap little etched foil reservoir in place of a larger, rarer and more expensive high ripple current replacement. Overheating due to AC dissipation can cause inadequate capacitors to run so hot they explode - especially in transmitters, of course.

This writer recommends that you avoid the use of NOS electrolytics. If you really must use one of these things, it is a good plan to reform the internal insulation of the component first by a slow, progressive build-up of voltage, fed through a 100kΩ 1W current limiting resistor to prevent excessive gas pressure.

Do not automatically assume that the negative poles of the HT reservoirs and smoothing capacitors are grounded. They sometimes are not. This is especially true of Racal RA17/117s and American radios with negative bias lines, an arrangement called “back bias”. The capacitor cathode may be at up to -50V with respect to chassis, as for instance on the National NC100XA. When using modern replacement smoothing capacitors, it is often a good plan to insulate the outside of the can from the securing clamp using Kapton polyimide film, or paper masking tape. Do not use PVC or PTFE tape because these materials are inclined to creep with time, leaving your radio with a shorted bias line and/or a loose HT decoupling capacitor.

It is often possible to fit one or more new wire-ended electrolytics inside the shell of the original smoothing block. This is popularly known as “re-stuffing” the capacitor. This job usually involves the use of a lathe to spin off the swaged lip retaining the rubber end-cap. [Pic064] The new internal components are best potted into position with epoxy resin or polyurethane foam, but do be careful to allow free air space around the blow-out plug or over-pressure vent. This is usually fitted into the rubber endcap, easily identifiable as a little round dimple.

Tantalum capacitors are seldom seen in valved communications receivers. The wet Plessey “Castanet” types are very troublesome, and should always be replaced. The Collins R-390A uses a single Tantalum capacitor in its audio module. This component is used for cathode decoupling and tends to lose value over the years, so that it is a good idea to fit a modern one when working on this part of the radio.

11.5 Barretters and Urdox Regulators

Barretters (ballast tubes) are very fragile. They must not be subjected to any mechanical shocks, and must not be mounted in strong magnetic fields. They also tend to be scarce, though some Amperite types (for instance, the 3TF7/TJ311M01 for the Collins R-390 and R-390A receivers) are still available ex-stock from the original manufacturers at the time of writing. Whether currently available or otherwise, all barretters are becoming increasingly expensive to replace. If the correct barretter is unavailable, it is possible to use a resistor of suitable value and rating instead.

Because a barretter comprises a glowing Iron filament in a Hydrogen atmosphere, there is the possibility of an explosion if the envelope has developed a very slight leak to atmosphere. When running up an unknown barretter for the first time, it is very wise to make sure all the radio covers are in position. This writer has only ever had one barretter burst, but it was a huge Osram 302. There was a most impressive bang, and glass went absolutely everywhere inside a 1940s PSEI HU52 domestic receiver.

In the event of non-availability of the correct barretter for your chassis, the use of an over-current type is sometimes a viable way ahead. In this case, shunt the regulated heater(s) with a resistor drawing current equal to the difference between the current ratings of the correct barretter, and the one that is actually fitted. Over-current barretters need to have a voltage regulation window at least equal to the original component.

It is also permissible to use an under-current barretter shunted by a suitable ballasting resistor. The regulation worsens according to the fraction of the load current passing through the two components. Thus in order to maintain reasonable current regulation, this technique should be used only when 10% or less of the load current has to be sourced from the ballasting resistor.

Conclusions about a barretter's condition are hard to reach as a result of measurements taken when the device is cold. For example, a healthy Amperite 3TF7/TJ311M01 drops 12.6V at 300mA when the host radio is running, implying a hot resistance of 42Ω. In comparison, the same device measures only about 15Ω when its filament is at room temperature. Given the fact that the thermal coefficient of resistance for Iron is 0.00567/°C, this infers a filament running temperature of about 325°C, which seems entirely believable.

There is occasional talk in the press of using series rectifiers or series paper capacitors to replace, or partly replace broken barretters. If attempting such an approach, be sure to use a true RMS meter to measure the voltages and currents that result from your modification before putting the radio back into service.

All barretters run hot. Some of them run very hot indeed! This is intentional. The regulating action depends on the thermal circulation of the Hydrogen gas around the filament inside the envelope. For this reason, it is most unwise to use a contact-cooled valvecan where not originally fitted.

German and Russian equipment running from AC/DC mains supplies tended for some years to be fitted with an Urdox (Uranium Dioxide) filament current regulator. This device comprised a conventional Iron/Hydrogen filament barretter section, in series with an NTC thermistor made out of Urdox material. This should in principle have prevented the usual switch-on flare of the Iron filament, thus prolonging the life of the barretter section. A clever detail is that the thermistor element was located immediately above the Iron filament, ensuring a very low running resistance for the solid state element.

11.6 Bulbs

Bulbs require a lot more care than might at first be expected. Part of the problem is finding the things on the right base, in the right voltage/current combination, with the right envelope style, in a quantity sufficient for your chassis - plus a few spares. Ideally all brand new and from the same manufacturing batch.

Some bulbs perform crucial secondary functions such as controlling LT current distribution throughout the chassis heater chain, in which case the bulb ratings must be exactly as given in the handbook. The glass envelope style and size can also be critical in some applications.

For the sake of appearance and longevity in AC-only sets, it is often best to fit bulbs rated at 9V to radios having paralleled filament systems running at 6.3V. For series-connected bulb chains this is also very good practice, otherwise manufacturing tolerances may mean that one or more of the bulbs could fail prematurely due to voltage hogging. Keep an eye on the voltage distribution if you use this trick on AC/DC sets.

Bulbs mounted immediately behind translucent cursor discs or meter scaleplates need to be run particularly gently, to avoid discolouration due to heating effects. Don't push these bulbs too far forwards in their holders, otherwise scorch marks could form.

Some radios use resistance wire in the bulb circuit. On the Marconi CR100, the two bulbs are wired in parallel in the usual way, but the feed from the 6.3V bus on the chassis is a through a length of sleeved resistance wire. This helps the filaments last a long time, even on board a warship.

Look very hard at bulb wiring, as a matter of routine. It is often found in a fried condition due to past short circuits.

11.7 Trimmer Capacitors

Before any attempt at adjustment, it is recommended that you photograph, sketch or mark the position of all trimmer capacitors. Then move them all very slightly to prove that they do in fact rotate. Then put them all back to exactly their original positions, pending proper alignment.

Beehive airspace trimmer capacitors are inclined to suffer open circuit intermittency unless their threads are clean. This type can also suffer short circuit intermittency unless the rotor and stator plates are truly concentric, and completely free of swarf.

Ceramic trimmer capacitors tend to develop intermittent open circuits unless the compression spring is clean and correctly tensioned. They can also go noisy. This type can develop hard to find tracking/arcing paths across, or even through the dielectric, especially when used in crystal oscillator circuits giving a high level of combined DC+RF peak voltage to the component.

11.8 Potentiometers

Rotary potentiometers quite often give trouble. Slider types nearly always do. Check the end-to-end resistance of every single variable or preset fitted to the chassis. Some potentiometers used in American radios appear to have very thin resistive tracks, and can greatly increase in value if they have been used a lot.

Use Cermet or wirewound replacements for any components that carry DC, as in all BFO and VFO fine tune arrangements and some squelch and volume controls. Suitable replacements can often be quite difficult to find, especially potentiometers having reverse log (antilog) tapers, or taps along the track for tone compensation.

RF and IF gain potentiometers are often arranged as variable cathode resistances in the appropriate amplifier chain. This means that they pass maximum current towards the clockwise end of their travel. For this reason, antilog potentiometers are ideal even though linear types were often fitted in manufacture. If substituted in error, logarithmic potentiometers often over-dissipate per unit track length towards the high gain end, and quickly burn out.

Many types of potentiometer can be dismantled for cleaning. This often entails the temporary removal of an SRBP or metal rear cover plate. If there is no easy way to get inside, it may be necessary to drill a 1/16" hole in the body of the component. This need not be a problem if done carefully in the right place, and if all swarf is carefully removed afterwards.

Contact cleaner can often provide a permanent cure for noisy operation of resistive controls, and is definitely not a bodge if applied properly. To make sure the stuff doesn't go everywhere, avoid the use of aerosols if you can.

11.9 Crystals and Crystal Filters

Crystals are critically sensitive to the cleanliness of the quartz slice and its mountings. For 100% glass encased crystals not much can go wrong, since this type of packaging is truly hermetic.

Crystals in solder sealed cans are to be regarded as cheap types with a finite life, especially if the lead-out wires or pins were sealed with epoxy resin adhesive rather than glass. Crystals of this construction will normally drift LF with age, as the quartz slice gains mass due to progressive surface contamination from the flux residue inside the can. Ordinarily, provided the ambient temperature does not change too much, the rate of LF drift should diminish with time. Cold-welded sealed crystals in metal cases will drift LF much more slowly, and are almost as good as the all-glass types.

Any crystal of any construction drifting slowly HF with time is to be regarded as seriously defective. This problem is usually due to inadequate cleaning of the quartz slice after grinding. In all cases, HF drift is due to poor manufacture.

Most crystals encountered in commercial post-war receivers are of the synthetic quartz AT cut type. These have a zero frequency/temperature inflexion point at around the ambient temperature expected in normal service. For crystals used in ovens, the inflexion point may be at +70ºC, whereas filter crystals would typically have the point at +30ºC. It is thus important when missing crystals are encountered in a radio chassis, to identify the complete original specification before searching for a replacement.

Oven crystals that have previously been cooked because of a jammed thermostat are usually fit only for the bin. This is because renewed or accelerated LF drift in later life is nearly certain, even when the crystal is re-housed in a properly functioning oven.

For crystals in openable holders such as style J or FT243 packages used in filters, poor phasing notch depth indicates the need for cleaning. If used in oscillators, the telltale signs indicating the need for cleaning are a reluctance to start oscillating, low output from the stage, and/or a steady drift downwards in frequency. Use de-ionised or distilled water for rinsing. Tap water is not nearly pure enough. Do not use abrasives to clean the quartz slice, and do not re-use decomposing rubber gaskets on reassembly. Always make a new one. Avoid the use of cheap silicone rubber sealant. The acetic acid liberated during the curing process will not be welcomed by the surfaces of the quartz crystal mounting plates. Some of the more expensive silicone rubber sealants do not liberate acetic acid, and may thus be suitable.

Later radios tended to use block crystal filters. As the radio is tuned very slowly through the passband there should be no ripple worse than 3dB. If there is, the filter circuitry is probably defective. This may be confirmed if the LSB/USB switching causes drastic imbalance in the audio noise response even when the carrier crystals are running at the right frequency. Unfortunately in most cases the problem will be internal to the filter, although there is the possibility that it is only the external matching that requires attention.

11.10 Mechanical Filters

Mechanical filters often give trouble, especially the round emblem Collins ones. 455kHz and 500kHz variants exist, most needing 130pF terminations at each port. Any filters of this type that rattle, or appear to have loose innards should be viewed with grave suspicion. Bitter experience shows that they probably have decomposing sponge foam element supports inside. The earlier winged emblem types used a less flexible method of element support inside the casing. In their youth, these would not have worked quite as well as the round emblem types, but they certainly give far less trouble nowadays.

For all Collins types, both end coils should have the same DC resistance, often about 50Ω. The end windings should be insulated from each other, and also from the outer casing. Collins mechanical filters can go slightly lossy and develop passband ripple, but this can be difficult to diagnose without a gold standard available for use as a comparison. These components are not repairable, and can be extremely difficult and expensive to replace. Make sure that any capacitors responsible for keeping HT off the filter coils are the very best types you can find.

Collins Radio was somewhat lax in specifying the bandwidth of mechanical filters. Some R-390A filters labelled as 8kHz BW are little narrower than others marked 16kHz.

An alternative supplier to the US military was the Dittmore-Freimuth Corp of Milwaukee, Wisconsin, whose filters have blue labels instead of red. Their filters appear generally trouble free in service. Whitewater Electronics also supplied mechanical filters for the Collins R-390A. These units had yellow labels, and were also of good quality. [Pic063] Clevite filters also found their way into the Collins R-390A, but these are ceramic types rather than mechanical.

Collins used a standardised range of filter stacks inside a wide range of external casing styles. [Pic062] This opens the possibility of finding filters that are electrically suitable but which would require the chassis to be modified in order to fit them. Unfortunately some types, especially the B9A plug-in style used in the Collins 75A-4 are now extremely rare and expensive, so that this approach may offer the only practical way to fit a CW filter.

Kokusai used piezoelectric transducers to excite the disc stack, instead of solenoid coils. These devices were used by KW and other manufacturers. Their performance when new was excellent, but the long term reliability is again prejudiced by the use of foam material to support the filter element.

Marconi developed and used their own design of 85kHz magnetostrictive resonator for the Atalanta, using a single metal bar about 30mm long. These devices are inferior in performance to the multipole types covered above, but at least they seem trouble free in service. The bandwidth is only 100Hz with a very good shape factor due to careful neutralisation, and a smooth passband response which is excellent for copying slow morse under difficult conditions. These components look like ordinary IFTs, but with curious wire loops sticking out of the top and bottom end covers.

11.11 Thermistors

Thermistors are often used in series heater chains, to avoid the flaring of some valve filaments immediately after switching on, and/or to accommodate failure of one or more dial lamps. Thermistors used in this way are designed to run extremely hot. They should therefore be positioned well away from other components. Do not change them just because they look mouldy! Measure them first, after the set has been running for about 15 minutes. Generally they will be found satisfactory. This is just as well, because power thermistors are getting distinctly rare nowadays. Wrap the lead-out wires well around the anchoring tags and use HMP solder, if the component ever does have to be replaced. Leave a good length of lead, to prevent the thermistor from heating its mounting tags unnecessarily.

11.12 Non-thermionic Power Rectifiers

Do not leave in place Silicon rectifiers, where these are found bridged across original thermionic types by a previous owner. The voltage surge during the first ten seconds can be high enough to damage the insulation of wound components. The subsequent prolonged high running voltage can over-stress the output stage and output transformer.

For >100mA Selenium air cooled HT rectifier stacks, a convection fin was usually sandwiched next to each individual disc to keep things cool under load. Alternatively, the entire rectifier stack can be contact cooled by enclosing it within a metal box which is screwed to the radio chassis. HT metal rectifiers of all types are generally unreliable. The writer always replaces these devices with a high voltage Silicon rectifier in series with a wirewound resistor of about 180Ω/10W, aiming to replicate the original HT voltage under load. Do not underestimate the PIV requirement of the rectifier. A BY127 is always a safer choice than a 1N4007, if in any doubt about what to keep in stock.

LT metal rectifiers are also highly unreliable. Each should be replaced by a high current Silicon rectifier in series with a suitable power resistor. The value and rating of LT rectifiers and series resistors needs individual selection for each application. Make sure the cooling arrangements for the new components are satisfactory. Each individual diode can be shunted by a 47nF disc capacitor, to reduce switching noise.

The 0Z4 fullwave gas-filled rectifier had a period of vogue in vehicular radios powered by asynchronous vibrators. This device is electrically fragile. It is intolerant of incorrect reservoir capacitance (which should be 8uF or thereabouts), and this rectifier will not survive open circuits or short circuits for long. The 0Z4 requires a minimum of 330V peak starting voltage per anode and must deliver between 30mA and 110mA to the load, otherwise its service life will be very short. Thus if your radio has been running with a defective vibrator, or is a low current design that has operated for some time with slightly flat valves, you may expect to find the 0Z4 rectifier in poor condition. Despite not having a filament or heater, these devices do take some time to get going from cold. This is not in any way indicative of a faulty device. In normal use, the cathode becomes incandescent as a result of ionic bombardment, and then emits electrons in the normal way. Type 0Z4 is considered to have ended its service life when its forward voltage drop exceeds 25V at +70ºC ambient temperature.

11.13 HT Vibrators

Both synchronous and asynchronous types were used. Vibrators were very popular for low powered portable receivers running from batteries where the current drain did not justify the use of a dynamotor, or where space or weight was limited.

Most vibrators were relatively unreliable components, perhaps understandable when their mode of operation is considered.

Many types were sealed into cans inside which the guts were supported by sorbo rubber. Years of disuse will probably have caused severe tarnishing of the contacts because of sulphurous emissions from the rubber foam as it decomposed. Sometimes it is possible to revive an old vibrator by spinning the top off using a lathe, burnishing the contacts and then resealing it using the plastic top from an old aerosol canister.

The waveforms into and out of vibrators tend to be very spiky. This writer would caution against the use of an AVO8 or similar for taking AC measurements, because the form factors encountered are likely to differ very greatly from the 1.11 value which forms the basis of calibration for these multimeters in ordinary sine wave use. The best way of investigating vibrator circuits is with an oscilloscope, though the non-periodic waveforms can cause triggering difficulties. Use of a true RMS meter may be a good idea but care needs to be taken with the HF limit of measurement, which may cause the meter to under-read.

Because of the harsh current waveforms and because the switching frequency often exceeds 100Hz, vibrators place great demands on their reservoir capacitors. This is especially true in the case of synchronous vibrator circuits. Be careful to select a generously rated reservoir if replacement is required. If the original reservoir has a bulging rubber base seal due to excess internal pressure or has been weeping electrolyte through the blow-off vent, then it will certainly be necessary to replace it. Modern polyester-dielectric capacitors are so small that it may be possible to use one of these instead of a relatively unreliable electrolytic.

In the case of a reservoir capacitor that is running warm and providing low HT from a synchronous vibrator, it may be that one of the HT commutating contacts has burned open or welded closed. Alternatively, the reservoir capacitor itself may have gone extremely leaky.

Many popular vibrator types are now being made in solid state form. One supplier is Antique Automobile Radio Inc. in the USA. The writer has fitted their 12V 4-pin negative earth type 2015N into a British Army R209 Mk2 portable HF receiver. The new vibrator works fine and is of course totally silent in operation. The electrical hash level is far lower then before, so that SSB copy on the amateur 20m band is now possible for the first time. Positive earth and 6V versions of this vibrator are available with and without the electronic version of synchronous HT switching contacts. One minor complaint is that despite the sales literature claiming the 2015N to be a direct replacement for the original electromechanical vibrator, the negative input pole is connected to the outer casing. The original Wico device had a fully insulated can! The effect is to force this old radio to have a negative earth polarity, whereas previously its metal case was floating.

11.14 Non-thermionic Signal Diodes

Germanium diodes using external solder seals to the glass envelope, such as early 1N60s and all GEX diodes are best changed for later Germanium types such as OA90 or OA91 in the interests of reliability. Be careful not to use too much heat and do not bend the lead-out wires closer than 1.5mm to the glass envelope, for fear of causing tiny cracks.

Diodes that are entirely glass encapsulated seem to be very reliable in service. Just occasionally, you will find one that has gone a bit leaky, and hence noisy. A Silicon signal diode should never be replaced by a Germanium type, and the converse is also true.

In noise blanker circuits it can be beneficial to replace Germanium gating diodes by Schottky types. The lower capacitance of this type helps the gate to shut off more quickly, and the forward voltage drop is about the same. The writer has used the HP5082-2800 successfully.

Miniature metal rectifiers were used for AGC generation, desensitizing, noise limiting and even signal detection in some valve sets. The Marconi Atalanta is a good example, using no fewer than six identical metal rectifier devices in all, plus a thermionic double-diode. Each metal rectifier assembly actually comprises between 1 and 10 tiny discs in series depending on the type. The discs are squeezed together by a small helical compression spring. The entire stack is sandwiched between metal end plates which are hermetically sealed into a ceramic or epoxy tube. Each disc had a forward voltage drop of about 400mV when new. Old ones taken from valved radios often show a lot more loss than this, presumably due to corrosion and ageing effects. The PIV rating of each tiny disc is about 25V, with a forward current capability of about 1mA. More discs in the stack give a higher PIV rating at the expense of a higher forward voltage drop. Larger diameter discs allow a higher current carrying capability at the expense of higher capacitance.

In general, metal rectifiers of all kinds are unreliable and should be replaced during a major rebuild. This writer usually uses small Silicon diodes such as the 1N914 or 1N4148 to replace them in signal applications and 1N4004s in voltage blocking/gating applications, and has had no problems so far.

11.15 Electromagnetic Relays

In receivers, these devices are mainly used for squelch, aerial switching and oven control. They are responsible for a lot of faults in the “really puzzling” category, and thus deserve particular care during chassis restoration.

The most troublesome relays by far, are open types that have no form of protective cover. The next most troublesome, are plug-in types with unsealed plastic covers which clip into position. Unfortunately, most receiver relays fall into one or other of these categories.

Repair of most relays is straightforward. Contact resetting is permissible, provided the original order of make/break sequencing is maintained. Fine glass paper or better still, a magneto file is ideal for cleaning the contacts, but always finish off with a fluid cleaner such as methylated spirit. Never be tempted to use emery paper, even the really fine stuff. Carborundum is so hard that grit particles may become embedded into the contact surfaces. This can cause high resistance contacts, or even diode effects sometimes.

Relay coils give far less trouble than contacts, but they can occasionally go open circuit. This is firmly in the “bad luck” category of faults. Rewinding is generally possible. It is worthwhile pointing out that most of the 110VDC coil types of relay found in some Collins equipments are still manufactured and available from component suppliers in the US.

Because of the vast number of relay types that were manufactured, it is sometimes possible to construct a suitable relay for your application by using a bobbin from one unused relay, a frame from another, and a contact set assembled from yet more scrap pieceparts. All that is generally needed is a big box of old relays, some ingenuity and hours of patience to provide a workable solution. Even really complicated contact configurations can be built up this way. This route also offers the opportunity to beef-up the ratings of contacts that lead a hard life. So this approach may even be better than a brand new replacement relay in the very long term! The downside is that the "new" relay may not fit quite as neatly as the original one did.

Ideally, Gold contacts should be used for passing signals with no current. Alternatively, it may be possible to introduce a bleed current of some 2mA to keep standard (non Gold) contacts clean and reliable. Do not use Gold contacts in high current applications. The Gold is usually only a flashed finish, and quickly burns off. The low melting temperature of Gold sometimes means that Gold-plated contacts can fuse together if asked to switch high currents.

11.16 Thermal Time Delay Relays

These are octal or B9A glass devices found mainly in American radios, intended to delay the production of HT for typically 30s, 45s or 60s depending on the time delay rating of the relay. These components are little seen in British and European equipment because of the more widespread use of indirectly heated rectifiers, which did the same job in a different way.

Thermal relays are generally reliable. This is just as well because they are now getting expensive to replace, though most types are still available at the time of writing. Delay relays were made by STC in the UK and by Edison & Amperite in the USA, for instance their 6NO45T (6V AC or DC filament, 45s delay time, normally open contacts, B9A glass envelope).

11.17 Meter Movements

Sealed types give less trouble than unsealed ones, which is only to be expected. Old sealed meters can be very difficult to enter in the event of problems. All too often the bakelite case can break, or bits of mastic become loose inside the casing and jam the movement.

Many problems of stickiness or apparent stiffness can be cured without dismantling. One good trick is to attach the meter to a 1Hz NE555 timer, to swing the movement back and forth over its entire range for a week or so. On several occasions, this has effected a lasting repair.

Corrosion problems can sometimes be overcome by slackening the bearings very slightly.

One difficulty that seems to afflict Ernest Turner (Marconi) meters more than most, is de-lamination of the varnish coating that covers the moving coil winding. Flakes tend to fall off and jam in the gap between the magnet pole pieces. Careful use of some 24swg tinned Copper wire can often rake out the loose bits, restoring free movement. Be very careful not to disturb the hairsprings.

Loose glass is best scraped with a razorblade, and then bedded back down into a <u>thin</u> fillet of Evostik around the edge.

Broken glass is best replaced with new glass, rather than plastic, which causes too many static problems. Cutting new glass to the right shape seems not too difficult for skilled glaziers. The best source of glass is from a junked meter rather larger than the one fitted to your radio, though it has to be annealed before cutting.

On some radios such as the Hallicrafters SX28, the meter case was drawn from sheet brass. The metal is often found cracked into sections splayed apart like flower petals. This was caused by stresses created during the manufacturing process resulting in "season cracking". [Pic065] To bind the whole lot together and keep dirt out after overhaul, the writer likes to wrap the case with masking tape and then secure it with an automotive hose clip.

11.18 Headphone Sockets

Sockets which have switches to change over the output of the transformer from a dummy load and/or loudspeaker to the headphones when a jack is inserted, very often suffer from dirty contacts. The usual symptom is a lack of output, but rarely a total absence. Most of the time, all that is needed is for the contacts to be cleaned with methylated spirit.

Most headphone sockets are wired with respect to chassis, but not all are. For example, neither pole of the Hallicrafters S36 headphone socket is grounded.

11.19 Loudspeakers

The small types found in many communications receivers, especially marine ones, are a regular source of trouble. Repair is not generally practicable, and exact replacements are frequently unavailable. It is often best to fit a modern mylar cone type instead, since these seem to be more robust in service than the paper coned variety.

The ideal impedance of the replacement loudspeaker would be identical to the original. Failing this, a lower impedance will be satisfactory. It is generally unwise for the health of the output valve to use an 8Ω speaker to replace a 3Ω original unless the new speaker is shunted with a 4.7Ω/2.5W wirewound resistor, which wastes power.

The grill or fret in front of the speaker is decorative, and often needs work to look good. Expanded or perforated metal grills can be resprayed, but pressing-out any dents can prove very difficult. Woven speaker cloth can often usefully be washed. The writer usually clamps the speaker fret between clean white linen handkerchiefs while gently swilling in a bowl of warm water with the usual domestic detergent. Scrubbing or rubbing is not allowed as this may result in fraying of the edges. Superglue can be useful for tacking the fret in position prior to fitting its securing screws. Many types of grill and fret material remain available and there are specialist suppliers to the vintage radio community.

12. Faultfinding and Realignment

12.1 Checks on First Power-up

Before power-up, first check the integrity of the mains earth connection to chassis. Have a good look inside the plug top checking the security of all connections, the cable captivation, and the fuse value & type. Then check for HT shorts. If there is only a 2-core mains cord, apply a solid earth to the chassis at this time.

WARNING: AC/DC sets must not have their chasses earthed unless running from an isolation transformer; and not all radios fitted with mains transformers have an isolated chassis. Examples exist of radios with transformers which nevertheless have the chassis connected directly to one side of the mains. This design type is most commonly found on Bush broadcast receivers.

It's a good plan at this stage to replace the mains filter capacitors with suitably rated modern components. Be especially careful to remove any Sprague BT, or Rifa types found connected to the mains. These types have proved very unreliable in service. If you haven't done it already, change the grid coupling capacitor to the output stage while the iron is hot!

After these preliminary checks, apply mains power progressively with the rectifier unplugged, using a variac and preferably an isolating transformer as well. Some restorers like to power the radio through a 60W incandescent light bulb at first, to give a quick and very visual indicator of health. Check for correct LT distribution. Then plug the rectifier in, wind the variac right back to zero and bring the voltage up slowly once again. If the radio uses a thermionic rectifier, it may be worthwhile replacing it temporarily with Silicon diodes for this test. This would prevent any risk of stripping the cathode or filament coating in the event of a serious fault such as a dead-short reservoir capacitor. Confirm the proper build-up of HT voltage and bias. Meter the HT supply voltage and current very carefully, and keep checking it for an hour. Do not use an auto ranging DMM where the decimal point position is not obvious at a glance. Make sure the HT reservoir capacitor runs nice & cool.

If a neon HT shunt regulator is fitted, make sure it strikes, and then regulates at the right voltage.

Bulb holders may not be at or even safely near chassis potential, so check bulb operation early on, and make repairs as necessary. On AC/DC sets, all valves need to be fitted otherwise the bulbs will not light. It's well worth getting the bulbs working at this early stage so they can provide a reliable indicator that the radio is running.

12.2 Initial Running Checks

When fully powered-up, check all cathode and screen grid voltages under zero input signal conditions. Then check all anode voltages.

Check carefully for high temperatures and burning smells. Listen for crackling, frying or hissing noises.

12.3 Alignment Prerequisites

Alignment may not prove as easy as you expect. Do not attempt it yourself without the right equipment, the right tools, and enough previous experience to "feel" when something is not right.

Alignment data is one specific area where handbooks are often incorrect. If your radio is known to be totally out of alignment, refer to the gold standard radio, and start by setting all cores and trimmers to the same physical positions as on that one. Never arbitrarily twiddle anything. Always be systematic and keep careful notes of what you are doing.

Marine radios which use 110VDC supplies such as the RCA AR8516L and also battery sets, will not give as much gain per stage as radios running on higher HT voltages. One piece of good news that results from this, is that these low voltage sets are very immune to RF and IF instability problems.

On unusual sets for which you have no information, and which refuse to tune up, be on the alert for the possible use of harmonic mixing. The Marconi Atalanta is one radio that used this technique on the HF range of coverage, because the RF valves are mounted outside the coil box to improve accessibility for servicing. Stray capacitances were such that the top range uses the second harmonic of the LO to track the signal circuits. Their earlier Marconi CR100 used the same mechanical design but did not suffer this problem, possibly due to the use of grid cap valves or because of the smaller number of ranges covered.

12.4 Coilformer Core Positions

Cores usually tune-up at two positions in the coil former. Selection of the correct peak can be absolutely fundamental to proper operation of the stage. The tuning core should be fitted at the correct end of the former, as decided by the radio designer. This is especially important for two reasons:

a) When the coil is tapped near one end of its winding, the effective tap ratio depends on which end of the coil gets the extra inductance due to the core.

b) When two (usually IF) coils are coupled by proximity, the coupling constant again depends on which ends of the coils get the extra inductance due to the cores. If both of the coupled coils have adjustable tuning cores, there is only a 25% chance of getting the correct mutual inductance by random selection from the four available peaks.

The following information is submitted as rule of thumb for use when you have no documentation, or where you do have it but believe it to be incorrect and have no access to a gold standard radio.

RF/LO cores on brass leadscrews: use the peak which places the Iron core furthest from the lead screw support nut, to give correct inductance temperature compensation (least positive value of dL/dt).

IFTs: the two cores are to be furthest apart in the former, to give the lowest mutual inductance between the two windings.

Exceptions to these guidelines do exist.

12.5 Double-tuned Transformers

Where alignment instructions specify that one side of an over-coupled double tuned transformer is to be resistively damped whilst the other side is adjusted, you will not get the correct response if you try adjusting the transformer any other way unless a network analyser is available, and you know how to use it properly.

12.6 Tracking the LO to the Dialplate

First make sure the tuning gang closes exactly at the dial zero point, or wherever else is correct for the radio you are working on. The scale tracking of the local oscillator may then be found incorrect, even with a completely clean variable capacitor. If equally bad on all ranges and the errors are all in the same direction, you may consider bending ("knifing") the local oscillator plate vanes. This is an iterative process, which must be performed very carefully, especially if there is HT across the plates. It can take ages.

If the problem is unique to one range, check the local oscillator padder capacitor for that range straight away. Do not adjust the plates of the variable capacitor, in an attempt to cure this fault.

12.7 LO Frequency Jumping

Oscillator frequency jumping is a common problem, and can be very difficult to fix. Sometimes a full cure is impossible.

If the problem occurs equally on all ranges, first check that the problem is not actually the BFO. Then check the LO by listening to it on another radio. If the phenomenon occurs only on the higher frequency ranges of coverage of dual conversion radios, check the 2nd local oscillator the same way. Then check the following, for both the 1st LO <u>and</u> the 1st mixer.

1. Condition of supply, grid and cathode resistors and bypass capacitors.

2. Variable capacitor earthing straps/springs.

3. Band change switch/turret contacts & grounding springs.

4. Security of RF/LO/mixer screening plates and bulkheads.

5. Local oscillator and mixer valve socket contacts.

6. Integrity of temperature compensation capacitors.

7. Integrity of low value mica and ceramic resonator capacitors.

8. Broken soldered earth seams on the chassis – GEC BRT400 family especially.

9. Complete freedom from dry joints. It's necessary to look very carefully indeed, because any obvious dry joints would have been caught by the factory inspector.

The final possible cause is excessive oscillator output, causing slight mode-changing due to parametric oscillations and overdrive. Try a slightly weaker local oscillator valve, or add slight loss into the oscillator circuit to reduce its loop gain by 3dB or so.

12.8 Aligning the RF Stages, Mixer Grid and IF Trap

Alignment of the RF stages ahead of the mixer should be performed first. This is usually straightforward. The only points worthy of particular attention are to ensure the correct RF sideband is selected rather than the image, and to use the correct source impedance connected to the antenna terminals.

Sometimes, one of the aerial coils is found melted or open circuit. This may have happened because of lightning, or maybe a transmitter was accidentally connected to the receiver input at some time. If this kind of damage is found, be alert for fried resistors and damage to the input bandswitch wafer.

Depending on whether the mixer valve is an inner grid local oscillator modulated (6A8, 6K8, 6SA7, 6BE6, Ediswan Mazda 6C9) or an outer grid local oscillator modulated (6L7, 6J8, ECH35, ECH42, 6E8, X61M, X65, X66) design, the presence of the first mixer valve will increase or decrease respectively the unloaded Q of its signal grid tuned circuit when the filament of the mixer is energised. This means that all else being equal, it is reasonable to assume that a radio with a 6SA7 first mixer will exhibit better image rejection than a similar radio designed around a 6A8.

In general, inner grid modulated mixers give worse local oscillator stability than outer grid modulated types. Bearing in mind the prevalence of the LO drift problem at HF, there is thus the possibility of swapping say, an original 6A8 for an ECH35 in an old radio that is regularly to be operated above 15MHz, even though there would be some slight loss of image protection.

Some mixer circuits are partially neutralised, even where the circuit diagram does not show it. The RCA AR88D is one radio that has invisible neutralisation. This technique gives an improvement in the symmetry of the RF tuning response if the circuitry is correctly designed, and if the hardware and layout has not been butchered over the years.

All of the foregoing means that it is necessary to take much more care over the alignment of the mixer signal grid circuitry than would at first appear necessary. The best way is to align for a noise (not a signal) peak after first setting up the RF amplifiers, provided you can be sure to avoid selecting the image. Otherwise, keep rocking the tuning back and forth slightly during alignment, whilst listening to a weak modulated wanted signal. Tune the mixer grid circuit for the peak audio SNR.

At the end of RF and mixer alignment, verify the tracking accuracy at both ends and the geometric mean of each band by offering up a ferrite/brass double-ended tuning wand to each coil in turn. The ideal is for each end of the wand to reduce the gain as it approaches each coil. Errors greater than 3dB per stage should be investigated. Start by removal and measurement of the padder capacitor, especially if of mica construction. The values were usually special, and normally require replacement by a network of standard components in order to get the value required.

Most tracking arrangements were intended to be correct at only three places in the band, and it may be that the central design frequency of your chassis does not coincide with the geometric mean. Furthermore, some radios had tracking errors built in from the day they were made. The B40 is one radio where a revision of tracking arrangements occurred during the production lifetime. Tracking accuracy can be regarded as very much a matter of design quality with these old radios, and rather variable from sample to sample of any one type.

A particular caution applies to the HRO family. In the event of tracking problems, first verify that the coilpack contains the correct mix of tuned circuits for your particular radio chassis. Differences exist between octal and UX styles of coilpack.

If fitted, the IF trap should be adjusted with nothing wired to the antenna terminals, but with the centre conductor of the signal generator output cable running at a high level held very close by. In this way, a very loose and undamped coupling is achieved to the radio antenna input tuned circuit. Under these conditions, the usual series resonant IF trap will give a very satisfying notch. For a single conversion radio, a good place to set its dial whilst performing this adjustment is a quiet frequency somewhere near 90% of the IF frequency. If multiple conversion, some experimentation may be needed. A good place to start is to set the radio dial 10% removed from the first IF frequency in either direction.

12.9 IF Response Problems

With an IF circuit that uses switchable or variable means of controlling mutual inductance in its IFTs, the passband can usually be made to achieve reasonable expansion symmetry as the bandwidth control is adjusted, at least under weak signal conditions. In general, the central trough in the passband response will remain on the same frequency as the coupling is varied. With strong signals, marked asymmetry is sometimes seen, with skewing of several kHz being fairly common on the widest bandwidths. This is due to Miller effect, transferring differing values of tuning capacity across the valve as the AGC varies the operating conditions of the stage.

Attention to IF strip decoupling often pays rewards, and it is wise to make sure all the IFT can and valve socket grounding screws are good and tight. The addition of a small undecoupled cathode resistor in all but the final IF stage can prove a useful modification in extremis. Try 47Ω first. This negative feedback will greatly reduce the severity of any Miller effect problem.

IF designs using switchable or variable top capacitive coupling to vary the passband width are fundamentally incapable of symmetrical bandwidth expansion, so this technique was not often used except in the cheaper sets. If you are restoring one of these things, do not expect too much. The trough of the IF response will vary in frequency as the coupling is changed and nothing much can be done to prevent it.

12.10 AGC Checks

When it is believed that the general alignment is correct and the set is operating properly, it is time to look hard at AGC operation. Meaningful voltage measurements require a measuring instrument with a very high input impedance. The usual DMM or scope x10 probe is not good enough for this job because they give only 10MΩ input resistance, which is inadequate for measuring an AGC system running at maybe 2MΩ impedance. If at all possible, you should use a proper VTVM such as a Marconi TF1041C or TF2604. [Pic067] The 100MΩ impedance given by this class of measuring instrument gives negligible loading on even the highest impedance AGC systems, enabling accurate measurements.

Alternatively, a high voltage op-amp could be used as a voltage follower feeding an ordinary moving coil voltmeter. An ordinary 20kΩ/V type such as an AVO8 would work fine with an impedance converter such as this in front of it.

Look first at the AGC delay voltages, noting that delayed AGC was not always used - especially in American sets. When present, the delay voltages are usually produced from a valve cathode or from a potential divider from an HT line. Examine the way the set develops and distributes its AGC as the input drive signal voltage is progressively increased from zero. Ensure every stage that should receive AGC gets it in the right proportion, and in the right sequence of initiation as the input signal rises through the first few µV of aerial PD.

In the event of unexpected problems, one of the first things to check is whether the AGC detector is fed from an IF anode via a low value coupling capacitor. Any leakage in this component can cause extra voltage delay in the AGC operation, or conversely, can partially or wholly cancel the intended delay.

At the centre of coverage of the middle RF band, there should be a sharp knee to the RF i/p versus AF o/p voltage transfer characteristic of the radio. Use 30% AM at 400Hz for this test, on the narrowest non-crystal bandwidth position available on your chassis, with the BFO off and operating in AM mode. The sharpness of the knee is a good indicator of the general condition of RF and IF valves and the efficiency of the decoupling. A really sharp knee indicates a general absence of faults anywhere in the signal path.

A simple but useful measurement is the extent to which the audio SNR improves with RF signal level. Using the settings given in the paragraph above, first adjust the RF input to give 20dB of audio SNR. Then raise the RF input by 20dB. A well designed radio will now generate at least 35dB of audio SNR. Radios that pass this test handsomely include the Marconi CR100 and GEC BRT400. Radios that struggle or fail include the RCA AR88 and National HRO.

In the case of radios which distort at high signal levels with large modulation on AM, the cause may be modulation rise in the final IF amplifier. Check that the right type of valve is fitted and that the correct fraction of AGC is applied. This valve may be a straight type in comparison with the variable-μ specimens fitted elsewhere in the IF strip, and the correct amount of applied AGC may be zero. A good specimen is always needed as the last IF valve because this is the one which must develop maximum signal power, and which often works very close to its maximum dissipation rating.

In the case of 2-stage AGC systems found, for instance in the Hallicrafters SX28, it will be necessary to verify that each circuit is operating with the correct characteristics, both as regards bandwidth and DC output voltage. On this particular design, the set should work perfectly satisfactorily with either system disabled except under extremely strong input signal conditions.

12.11 Second Detector Issues

Second detector problems generally stem from the high impedance nature of the circuitry. This can cause difficulty in the event of even slight leakage in the circuit.

As with AGC systems, beware detectors fed via a small capacitor from a source of high combined AC+DC voltage such as the final IF anode. Any leakage in this coupling capacitor would cause detector distortion. Other more subtle problems are sometimes found, such as an unexpected squelch effect in the RAF R1155.

12.12 Noise Limiter Problems

Because most noise limiter circuits operate at very high impedance, all the usual problems with high value resistors and leaky capacitors exist.

Many halfwave limiters are supposed to be “self following” as for instance in the GEC BRT400. These are often referred to as automatic noise limiter (ANL) types. It is well worthwhile checking that they perform this function properly. A signal generator having simultaneously variable modulation depth and RF output level is most useful here, eg. the Marconi TF144H.

Fullwave limiter designs are rarer. These provide symmetrical waveform clipping according to the setting of the front panel knob, as on the Collins R-390A. Most of these types are not automatic (self-following) in their operation. Again, check by oscilloscope that all is well whilst driving the receiver over a range of RF input levels and modulation depths.

Hum problems are often due to heater to cathode leakage in the limiter valve, lack of filament DC bias, or excessive filament voltage. These causes all tend to result in hum at mains fundamental frequency. This fact is often useful as an indicator of the source of this problem.

12.13 Noise Blankers

Noise blankers are something of a rarity in receiving equipment of the valve generation. The only popular examples are the Lamb IF silencer found in the Hallicrafters SX28, and the VHF TRF design sometimes found fitted as an (expensive) option to Collins equipment, eg. the 136B-2 for the KWM-2 transceiver.

In general, these early noise blankers do work provided their components are satisfactory, and provided that (in the case of the Collins design) a suitable VHF lowband noise-collecting antenna is used. The use of loudspeaker wiring to do this job was suggested by Collins as a viable alternative. Unfortunately, in the computer-infested domestic electromagnetic environment of today, this tends not to work too well. A properly sited and designed VHF noise collection antenna mounted outdoors would work far better. You could even beam it directly at the noise source for optimum rejection, something emphatically not possible with today's generation of DSP HF receivers!

Blanker valves spend most of their time with hot heaters but with the HT switched off; or switched on but without frequent blanking pulses. Either way, cathode poisoning can develop unless special valves are used which are resistant to the build-up of interface resistance. The 6U8A valves in the Collins 136B-2 blanker could therefore usefully be type CV5065, GB-1252 or similar. These are premium valves which are more expensive than most - deservedly so.

Many noise blankers use Germanium diodes as the gating devices. These can sometimes usefully be replaced by modern Schottky diodes such as type HP5082-2800. The lower capacitance of these devices enables the blanker gate to shut off more quickly, and the forward voltage drop is about the same.

12.14 IF Notch Arrangements

An IF notch facility may be encountered. Other than the ordinary single crystal phasing filter, this function is generally provided by either a passive LCR network or a regenerative Q-multiplier operating around a triode valve or transistor. The capacitors in all of these circuits need to be truly excellent.

Be sure to avoid the use of excessive Q-multiplier gain. Otherwise, the superb notch you obtain during alignment may well turn into oscillation at a slightly different ambient temperature or line voltage.

It's generally unwise to try improving on the alignment procedure given in the handbook. One of the factory design engineers will have thought much longer and deeper about it than you yourself are ever likely to get the chance to, even if you have all of the necessary skill and access to suitable testgear.

12.15 Crystal Oscillators

Crystal oscillators give far more trouble than most people suppose.

Part of the problem, certainly with calibration oscillators, is that they are used so infrequently. A long period of zero anode current with the filament energised, causes progressive poisoning of the oscillator and/or harmonic generator valve due to gas ionic bombardment of the cathode surface. This causes the mutual conductance to drop far below what would be expected from the total running time of the valve, to the extent that the circuit may become partially or even totally non-functional. Here is another application for a valve resistant to the build-up of cathode interface resistance, if you can justify the cost.

Eddystone was one manufacturer clever enough to spot this problem, and address it head-on. Their S880/2 model provides a very small cathode bleed current when the calibrator switch is in the OFF condition. This is sufficient to prevent poisoning, but not sufficient to cause oscillation or even noise output. All in all, this is a very elegant solution to the problem, and indicative of a receiver design that was better than average in several other respects too.

Oscillator crystals need to have the correct specification if they are to start properly and then operate at the right frequency with the correct output voltage. For example, looking at an HC-6/U crystal marked "CATHODEON 1000KC" says nothing at all about the required circuit conditions. It could be a type intended for use in an oven or perhaps a crystal filter. Maybe even, it is a radio channel crystal whose actual frequency is 1.455MHz! Great care is needed.

12.16 Ovens

Some receivers use ovens to control the temperature of crystals and even, in the case of certain American military receivers (eg. Collins R-390) the entire VFO. This policy is fine so long as the thermostats do not jam in the closed position and cook everything inside.

In all cases known to this writer, VFO ovens can be switched off. This is recommended, unless the radio is to be operated continuously in areas having large diurnal temperature excursions.

12.17 BFO Injection

BFO injection is often at a very low level in old receivers. In fact, for quite a long time, this philosophy was distinctly fashionable in the industry. The aim was to avoid desensitising the receiver when the BFO was switched on, and to avoid pulling the BFO frequency under strong signal conditions.

Where the injection coupling is capacitive, especially in the RCA AR88D where it is by mere proximity, a great improvement in SSB reception capability may be made by the addition of a parallel twisted wire capacitor. Use just enough C not to initiate AGC action under no-signal conditions.

Sometimes, on sets with an inadequate level of BFO extra injection can be had for free just by a change of valve, for instance by swapping the EF91 for an EL91 in the GEC BRT400 family. Other sets had too much BFO injection, causing problems with the AGC. This may be cured several ways (eg fit a variable-μ valve or reduce the injection capacitor), or even ignored altogether as it is usually a very minor problem.

Much harder to deal with is the difficulty of restricted BFO tuning range as found for instance, in the National HRO-MX. One cure is to increase the number of plates on the BFO variable capacitor - assuming a reasonable number of donor chasses are available, of course! Three times the original number of stator and rotor plates may be fitted to the original frame using this technique. Coverage is then more than sufficient for CW, USB and LSB without any adjustment of the coil.

Injection locking of the BFO is sometimes seen. Here, the BFO appears to suck-in towards the zero beat position under strong signal conditions. Having acquired lock, the BFO will not release back to its natural frequency unless the input signal is greatly reduced in amplitude, or moved to a frequency well outside the capture range. This effect is particularly annoying on SSB, where it impresses severe syllabic rate FM on the demodulated audio. The Eddystone S940C suffers badly from this problem, despite (or because of?) having a self oscillating 6BE6 product detector. A partial solution can be achieved by improving the decoupling arrangements. No total solution has yet been identified by this writer. The good news is that this phenomenon does have a practical application. Given some operator skill, the S940C can behave as a useful synchronous AM receiver giving better results on selectively fading 41m band signals than achievable from its envelope detector!

12.18 Intermittent Faults

This type of fault is common in old radios, and can be extremely hard to trace. Usually, the cure is easy and straightforward once the cause of the fault has been positively identified. The trick is to avoid introducing secondary faults along the way.

First try to isolate the fault to a particular area of the block diagram, by swapping modules with a different radio of the same type. If this is impractical, it's time to start metering the radio extensively with a selection of scope probes and multimeters. Arrange temporary injection points in the IF and audio circuits, with coax tails coming from the radio. Be sure to monitor the local oscillator & BFO injection levels, which is often most easily done by measuring the grid current of the injected valve.

Suspect tubular capacitors and fibrous resistors should be squeezed gently with insulated pliers, to see if the fault can be made to appear on demand.

The use of a hair drier can thermally stress areas of the chassis, or even individual large components. This can be a useful way of introducing faults that normally only appear with the cabinet in position, after the set has been running for an hour or two. Beware of using freezer aerosol or a paint stripping heat gun, these are much too vicious. It is easily possible to break old components this way, melt lots of wax, or introduce more intermittent faults.

In sets that used a soldered chassis frame which has cracked apart, it is often a good idea to resolder whole areas of metalwork en masse, in case the fault is due to a dry joint in an important RF ground path somewhere.

The final solution is strictly for the desperate, and should only be used for thermal intermittent faults where all other avenues of analysis have already been exhausted. Be warned that this technique can cause secondary damage, but it usually does positively identify the original intermittent fault. Cover the radio with a fire blanket to block off all ventilation. Fit a thermometer or thermocouple probe in the airspace under the blanket at the top of the chassis. Run the set until the air temperature reaches about +75ºC (use +65ºC if your chassis uses waxed capacitors or coils, or was originally built with second-grade components). Open the blanket slightly at the bottom, and try to stabilise the temperature at this figure. Stay with the radio, monitor it very carefully and leave it to run until something fails. Usually, what fails is the cause of your original intermittent fault, but normally the failure will now be permanent, and therefore traceable. You really must be present all throughout this test, and have a suitable fire extinguisher readily to hand.

12.19 Identifying and Curing Unwanted VHF Oscillation

The technique of using a spectrum analyser and coupling link as a diagnostic tool (see later) for investigating anomalous receiver performance can often be helpful when chasing VHF instabilities. This problem has accounted for several instances of high noise levels, stage inefficiencies and strange intermodulation/spurious response phenomena in valve HF communications receivers seen by this writer.

VHF instability is particularly common in equipments that have been modified to incorporate hot front ends or mixers. The word “hot” can be used in the literal sense sometimes, if the oscillation is strong enough!

It may be possible to use a wave meter or general coverage VHF receiver to detect the presence of unwanted VHF oscillation, instead of a spectrum analyser. The level of oscillation is usually extremely high, and often has a frequency between 50MHz and 200MHz in practice, so start searching this band first. Put the probe in the centre of the anode box of each stage in turn, and sweep the band for unexpected strong signals.

If you are convinced one of the stages in your radio is unstable, there are three alternative ways of proving the existence of parasitic oscillations when a spectrum analyser is unavailable, as follows.

Technique No 1: Replace each RF amplifier, mixer, and RF oscillator valve in turn with a specimen approximately 50% down on mutual conductance. Very often it will be found that the flat valve has inadequate VHF gain to oscillate. So if adding a flat valve magically improves the performance of your radio, put the good valve back in and add grid and anode stoppers as described below.

Technique No 2: Add a small 47Ω resistor in the grid, and a small 10Ω resistor in the anode of each stage in turn, working from the 1st RF valve back through to the final mixer. Of course, this will identify the problem by curing it. The need to put the resistor directly on the valve socket contact does make this technique very fiddly to implement.

Technique No 3 (applicable only to high level oscillation): hold a small wire-ended neon in the anode compartment. Yellow glow indicates unwanted HF oscillation; purple/mauve glow indicates VHF. It is not necessary to connect the neon to anything because the neon is struck by voltage derived directly from the electromagnetic field radiated by the tank inductor of the unwanted oscillator. Note that this tank inductor may well be one of the wires in the anode structure, rather than a physical component such as a coil.

12.20 The Audio

Some radios use high slope output valves such as the KT81, EL84, N78, 6HF8 or 6EB8. These types can be inclined to RF instability, often on longwave or at VHF. The usual symptoms are excess HT current drain, or an unpleasant grittiness/scratchiness to the audio quality. It is worth trying a grid stopper of 1kΩ in series with the control grid right at the pin, and 10Ω in the anode line - again, right at the pin. In difficult cases it is worth trying 100Ω in series with the screen grid as well.

12.21 Post-alignment Tasks

Except where ventilation is critical, this writer would recommend covering all trimmer adjustment access holes with PVC tape after alignment has been completed. This advice extends especially to holes in the top of IFT cans, under which lie beehive capacitors. These devices are particularly prone to going dead short given the slightest encouragement from dust, swarf etc falling onto them from above through the access holes. Some IFTs of this design are incredibly hard to remove for repairs. The GEC BRT400 types come immediately to mind.

13. Permeability Tuned Radios

This topic definitely deserves a section all of its own. Radios in this category are usually American, always multiple conversion, and tend to date from the 1950s and 1960s. In general, one or more RF stages are mechanically ganged to one or more tracking IFs and a VFO.

A permeability tuned VFO (often called a PTO in original documentation) is invariably used on American models, whereas the British tended to use a tracked capacitor VFO as for instance, in the Eddystone S880/2. Some American sets used a permeability tuned BFO (eg Collins R-390/R-390A) but others used an ordinary variable capacitor (eg Collins 75A-4).

Two basic mechanical systems were used. LF radios such as the Collins R-389 requiring large fractional frequency coverage used leadscrew techniques to raise and lower the slug racks, and this technique was also used in the Eddystone S880/2 HF receiver. The Collins HF receivers used snail cam-operated cams and roller followers to control the slug racks, rather than leadscrews.

13.1 Module Interdependency

All of the Collins-designed receivers in this category are modular in their construction, even the little R-392 mobile radio. Before contemplating any surgery or realignment, it will be essential to have a thorough understanding of how the various modules interact with each other electrically and mechanically.

On the American equipments, the screws that hold the modules onto the chassis are usually 6/32UNC with Phillips round heads, painted green. Do not be tempted to remove any red-painted screws without a thorough search through the handbook first. [Pic069] Red screws are rarely found, but normally indicate fastenings which ought not to be disturbed. In extreme cases, red screws could cause danger if removed, for example as a result of suddenly released turret springs or a dropped mains transformer.

The screws found elsewhere in American radios are mostly 3/48UNC or the larger 4/40UNC and 6/32UNC sizes. Phillips heads are similar to Pozidriv, but without the extra guide flutes of the European system. It is therefore important to use the right screwdriver, especially on the tighter 6/32UNCs. Most Phillips drivers have red handles, whereas the Pozidriv ones tend to be blue. Unfortunately, UNC hardware is rather hard to come by in Britain, and most of the smaller stuff that is available has Pozidriv heads.

Some designs retain their mechanical integrity when disassembled into modules, while others do not. The Collins R-390 is an example of the latter category. This chassis requires a green-painted tinplate idler gear to be fitted to the RF unit, before it is removed from the mainframe. [Pic070] This gearwheel must not be disturbed until the module is back in position. This little piecepart avoids the counter, which is mounted on the RF module, from getting out of alignment if the module's own kHz mechanism is rotated. The later Collins R-390A maintains its integrity when dismantled into modules. The gear train mechanics on any one of its modules are independent of all the rest. It would certainly be far easier to assemble a working Collins R-390A from a random chassis frame and full set of working modules, than would be the case with the equivalent set of parts for one of the earlier Collins R-390 receivers.

13.2 Bristol Multiple Spline

The Collins radios, and others of their design made by manufacturers such as Motorola, EAC, Bendix etc all make liberal use of grubscrews of the Bristol Multiple Spline type, often erroneously called Bristo even in official documentation. These screw heads are NOT the same as the Allen or Torx patterns, and they are not widely available in the UK.

You will need at the very least, Xcellite tool number 99-66. If you or a previous owner has attempted to use an Allen key, it may be necessary to drill out the grubscrew. This is difficult since the material is very hard.

Some grubscrews were locked at the factory with Glyptol, which is a type of green varnish. To free a Glyptol-coated grubscrew, one good way is to heat its core for 10s with a fine, very hot instrument soldering bit. Then quickly crack the joint with the Bristol key.

13.3 Tuning Slugs

It will be essential to start by having the right Iron cores in the right formers. The slugs are usually colour coded with a dot pattern visible from the top. Some designs of chassis use up to four deliberately different types of core. If one wrong core is used somewhere in a slug rack, that section of the receiver may not align at endpoints, and/or it may fail to track correctly.

Beware cores that have become detached from their lead-out wires. Repairs are very simple once the loose core has been pulled free of its former.

Sometimes there were mid-production changes to the types of cores used in one or more of the slug racks. Very often, either the earlier type or the later type may be used without any changes, provided they are fitted as a complete set.

The slugs must move freely in their formers. These pieceparts must be truly coaxial in their alignment. Radial adjustment is usually provided for, often by means of movable supports for the slug support wire. It is permissible to use a trace of MS4 silicone grease on the outer diameter of the slugs, in the event of major binding problems.

13.4 Mechanical Alignment

Initial mechanical adjustments should be performed with the VFO declutched from its drive shaft. Set the dialdrive endstops to allow symmetrical over-travel at each end of the MHz and kHz ranges. Make sure the LF and HF MHz and kHz endstops work properly. You have four to check and adjust, in all. Repairs are often necessary, especially on early Collins R-390 receivers.

Set the calibration clutch to the middle of its travel. Make sure this humble mechanism works properly. Repairs are often needed and may as well be performed now, rather than later. Collins-derived radios seem to have fragile calibration clutches.

Check that all sprung split gears are properly preloaded. Then make sure the Geneva mechanism that drives the octave coil selection wafer switches is correctly adjusted, and properly ganged to the MHz readout cylinders.

The mechanical counter display needs to have fully functional "-" and "+" rollover display cylinders. These should appear when the kHz shaft is set to below 000kHz, or above 1000kHz on any MHz range, heading towards the adjacent mechanical endstops. Typical limits of travel will be indicated as -966kHz and +034kHz as the endstops engage. Note the symmetry of these wraparound numbers.

Next, check that the MHz crystal oscillators, and any associated frequency multiplier coils, are properly selected by the drive shaft feeding from the band change mechanism. Dial up the “magic number” given in the handbook (this varies from model to model), and set all the cams to exactly the right positions. This should result in a properly aligned gear train, onto which the VFO can now be tracked.

Finally, set the VFO to track the kHz mechanism, and then lock up the grubscrew. Be absolutely sure at the end of your work that the main dialdrive endstops activate <u>before</u> the follower nut inside the VFO canister runs out of thread on its leadscrew.

The VFO Oldham coupler, and all others in the chassis, should have about 0.75mm endfloat. The anti-backlash spring should be present and functional.

13.5 VFO Alignment

VFO endpoint adjustments vary from model to model. They do all have an ability to be set to exactly the right frequency at the 000kHz and 1000kHz points or at least, they did when they were new. Typically the endpoint adjuster is hard to get at, sealed by a screw plug, and delicate. Not a nice combination! Frequency tracking across the range is set by internal adjustment, but should be within 1kHz (500Hz when new) anywhere between the 000kHz and 1000kHz endpoints. The error is allowed to worsen between the endpoints and their adjacent endstops.

The VFO tuning ranges of the Collins R-390 and R-390A receivers can be adjusted in the chassis, though the handbooks say otherwise. Target 2.455MHz to 3.455MHz from the VFO, over exactly ten turns of mechanical rotation. If this cannot be achieved within the adjustment range of the endpoint adjuster, the VFO will need internal surgery to remove some inductance from the small coil in series with the large main coil.

Messing with the tracking is probably best avoided, unless your pocket is deep enough to afford another VFO if things go wrong. The only American VFO type that seems to give incurable problems with tracking is the Cosmos, a late species of R-390A VFO. Most other types, including the Collins original, are generally there or thereabouts after half an hour of careful adjustment.

13.6 VFO Repairs

If your permeability tuned VFO is unpleasantly lumpy in its motion, or is known to cause frequency jumps, it will be necessary to go inside and relubricate the mechanism. [Pic071] On supposedly sealed units, you must disregard all of the cautions on the labels outside the can relating to sealing integrity.

Use heavy mineral grease on the corrector stack mechanism and its follower. Apply EP90 hypoid oil to the endthrust bearings. Sealing O-rings should be lubricated by MS4.

Do not bother to dry out the silica gel cartridge, if found. It is only there for show, the assembly never was truly hermetically sealed. If you do go to the trouble of drying it out, all that will happen is that you will have to reset the VFO endpoint adjustment in six months time, compared with two years if you leave it well alone. This is because during that first six months, the silica gel will dry the coil, which then shrinks slightly. After about six months, the moisture ingress past the seals will start to cause the coil to swell again, as the silica gel sack loses control of humidity inside the canister. The endpoint adjuster will require tweaking with each change of dimensions of the VFO coil.

Inspect most carefully, the follower nut that runs on the finely threaded leadscrew. On some designs, this nut is carried on a sprung cage, the fingers of which can break. This is one identified cause of backlash. Repairs generally prove possible, but it is important to retain some sort of spring-loaded flexible mounting arrangement for the nut.

Lubricate the input shaft grounding spring after making sure it is bearing lightly on the shaft.

After refitment to the chassis, always switch the VFO heater oven OFF if possible.

13.7 VFO and BFO Operating Shafts

The shaft carrying the tuning knob is often supported by an adjustable bronze bush in the front panel. Permeability tuned radios tend to require large operating torque, even when everything inside the radio is working properly. Extra friction introduced by a wrongly adjusted support bush should be avoided, but this fault is nevertheless quite commonly seen. Be sure to adjust the position of the lockable bush last of all, preferably just before the radio is to be fitted into its cabinet. Obviously, in order for the bush to be effective, the shaft must be dead straight. Gentle bending with an adjustable spanner can prove effective.

All permeability tuned BFOs seen by this writer, have input shafts in the form of a very fine leadscrew. Often, this is connected to the operator's shaft by a bellows coupler. Make sure the coupler is at its natural unstretched/uncompressed length, with the BFO set to the centre of the IF passband. Comments relating to relubrication of the internals of the BFO canister are generally as for VFOs, though the job is easier due to the absence of a tracking corrector stack.

Any shaft grounding springs must be making contact properly and be well lubricated to avoid galling of the mating surfaces.

13.8 VFO Types Other than Collins

Drake permeability tuned VFOs never seem to give problems, and rarely need adjustment despite their relative simplicity. They track within 1kHz, even though the ferrite arrangement looks really crude. Overall, the Drake VFOs surely represent a more elegant engineering compromise than the Collins approach.

British precision VFOs found for instance in the Eddystone S880/2 and Racal RA17 tend to use high quality variable capacitors from the likes of Wingrove & Rogers, rather than permeability tuning. They generally benefit from replacement of doubtful looking ordinary Rs and Cs, but never seem to require retracking.

13.9 PBT as Used in Collins Designs

The PBT arrangement used by Collins in the 75A-4 relies on rocking the VFO frame in synchronism with movement of the BFO capacitor, using a spring-loaded bronze belt & pulley arrangement. [Pic072] It works very well in practice, though there are two special points worthy of mention.

The right valvecans must be used, these being of slightly shorter than standard height. This is to stop the VFO cans hitting the support frame at either end of the PBT travel.

VFO subchassis earthing and bearing endthrust, are tasks performed by a single wavy Beryllium Copper washer behind the VFO canister. This component needs to be present, undamaged, and properly adjusted. Experience leads to a firm caution against the use of an ordinary plated spring steel replacement.

13.10 Setting the IF Gain on Collins Designs

One of the last adjustments to be performed on the Collins family of permeability tuned radios, is the IF gain level. The handbook shows how to set this to the minimum value consistent with giving specified sensitivity performance. This adjustment procedure should be followed exactly, in order to achieve the best possible dynamic range. Any Collins designed radio needing its IF gain control set to maximum requires attention.

14. Performance Benchmarks

This section outlines the key performance measurements needed to verify the health (or otherwise) of your radio. Figures of typical performance are presented, and a star performer is identified for each category. For consistency, these are drawn from the popular 2RF + multiple IF, single conversion category (RCA AR88D, National HRO, Hammarlund SP210, GEC BRT400, Hallicrafters SX28, Marconi CR100/B28, Eddystone S940C, Murphy B40 etc) having an IF of 455kHz or 500kHz.

14.1 AGC Threshold

Radios having two RF, and two or more IF stages usually start developing AGC at about 2μVpd input. Thereafter, a +100dB RF step should generally result in <+9dB rise in AF output. For radios having one RF or IF stage fewer than the above, the AGC action typically starts at about 4μV, above which a +80dB RF step gives <+9dB audio rise.

Maximum AGC voltage varies from about -10V on radios having simple AGC circuits, to -45V in the case of radios having complex AGC distribution arrangements and AGC amplification.

The star AGC performer in the writer's collection is the GEC BRT400K, for which a +100dB step above 3μV gives +2.5dB AF. This set has separate RF and IF AGC voltage delays, a complex anode bend AGC detector, and feeds only a part of the available AGC to the final IF (6BA6) stage. Further evidence of excellent AGC management in the GEC BRT400K is the way the recovered audio SNR rises rapidly and progressively with the RF input signal level. Certain other radios are able to match this receiver for audio levelling, but none yet measured by this writer does as well on SNR recovery in the difficult 1μV to 10μV signal region when receiving an AM signal.

The GEC BRT400 family uses an archaic S130P HT regulator for its oscillators and RF/IF screened grids. This type shows unusually large sample-to-sample variability as regards actual regulated voltage. A good sample is needed for the GEC BRT400K to give its best AGC performance.

14.2 Noise Figure

If a noise generator such as an R&S SKTU is available, it is easy and worthwhile to measure the receiver NF on the 10m band. This may measure as low as 6dB for sets with 2 miniature RF amplifier tubes, or as high as 18dB for radios with only one first-generation octal RF amplifier tube.

The truth is that noise figure on the HF bands need not actually be better than about 11dB for normal terrestrial shortwave reception. Of the vintage manufacturers, only Collins, Drake and Racal seem to have properly understood this. Other manufacturers generally produced receivers that had excessive gain, and hence suboptimum dynamic range.

The writer's star Noise Figure performer is the Eddystone S940C, for which a genuine 5dB NF can be reliably recorded on 10m. This makes it very suitable for use with low gain, low noise UHF down-converters. This radio has an RF architecture employing a cascode ECC189 feeding a 6BA6 second RF amplifier, then a ECH81 mixer. An excessively gainy design, but very sensitive indeed.

14.3 Image Rejection

For single conversion radios, it is instructive to measure image rejection on the 10m band. Radios with 2 RF stages, having ceramic or plastic valve sockets & wave switch wafers, air spaced trimmer capacitors and large coil formers of high quality material usually give 40dB image rejection when properly aligned. For radios fitted with bakelite valve sockets, paxolin wave switch wafers, ceramic trimmers and small moulded coil formers, 25dB is more normal. Each of these dB figures will be halved if the radio has only one RF stage, unless clever inter-stage coupling is used to improve performance as on the British Army R107 for instance; or unless a 1.6MHz IF is used as on some Eddystones.

The LF skirt of the overall RF selectivity characteristic will usually be steeper than the HF skirt so better image rejection will be obtained from radios which run their local oscillator LF of the signal frequency, even though this will be at the expense of tracking difficulties that may restrict the tuning range.

The writer's star performer for image rejection is the RCA AR88D, a genuine 42dB of image ratio being achieved on 10m when running with its local oscillator LF of signal on the top range. Is this the only example to track correctly this way? The handbook indicates that this is not how the radio ought to be aligned. (The writer suspects that the handbook is wrong.)

For proper image performance, the radio should be fed from the source impedance specified in its handbook. This applies to alignment, testing and actual service. If the radio has a balanced input, especially one that has to be adjusted for correct balance as well as for resonance, be sure to feed it from a balanced source of correct differential impedance. For alignment purposes, this may often be achieved by a toroid and a network of impedance stabilising resistors.

14.4 Third Order Intercept Point

This is a two-tone strong signal performance parameter. In the context of HF receivers, it is the RF input level at which each of the two (unwanted) third order intermodulation products would appear of equal amplitude to each of the two fundamental (wanted) signals. In reality, HF receivers always start to compress way below the level of the third order intercept point. Therefore an extrapolation technique has to be used to determine the position of the third order intercept point, based on measurements of the 2-tone intermodulation behaviour while the receiver is operating within its linear range. Third order intercept point is somewhat time consuming to measure properly on an individual basis, but can become quite quick when performing a batch of measurements together as a group. This parameter is especially important for those intending to select a vintage radio for serious use on about 7MHz after dark in the winter months, with a good aerial.

Two cautions are required regarding the measurement of third order intercept point:

a) This tends to be an inaccurate measurement because of the threefold multiplication of dB errors in each of the two signal paths.
b) Healthy samples of any given radio type can give significantly different test results. This is often due to small differences in gain throughout the receiver architecture, or different valve curvatures.

There is little advantage in having third order intercept points in excess of 0dBm, at least for everyday HF operation with ordinary antennas. When the receiver is to be co-sited with an independently operated large HF transmitter installation, or when high gain VHF/UHF down-converters are to be used in front of the HF receiver, then there may be functional benefits to be obtained by choosing a receiver with an intercept point above +10dBm. Realistically, only solid state receivers are likely to achieve this figure. The best bet for an old valved receiver working under such conditions of excessive RF input is to insert a 20dB pad in its antenna input line. Most of these sets have 10db to 20dB of excessive sensitivity on the LF bands, which may as well get sacrificed in the search for better overall performance. The beneficial effects of a 20dB input pad include a 60dB increase in third order input intercept point and a 100dB increase in 5th order. The result especially on the LF bands will be to make the receiver appear extremely deaf on air. Good! This says that many unwanted spurious responses have been very greatly reduced. See how clever is the Racal approach used on the RA17L and RA117, in fitting a multi-step aerial attenuator as standard. The puzzle is why more manufacturers did not do this. Even Collins missed this rather obvious trick. The technique of seriously detuning the antenna resonating trimmer is very much a second best, but this is all that can be done on most old sets.

This writer normally measures third order intercept point on 10m, since in the case of multiple conversion receivers, by choosing different tone separations the performance of the first and second mixer chain can be analysed separately. In the case of tunable first IF designs such as the Collins 75A-4, tones spaced at 20kHz will pass straight through the RF and first IF systems, so that the performance limitation will usually stem from the second mixer. With 100kHz spacing, both fundamental tones and the third order intermodulation products will still pass through the nose of the RF tuning, but the most remote tone will generally now be sufficiently far down the skirt of the first IF response for the second mixer not to be subjected to these two strong tones at the same time. The measured performance will then be determined by the first mixer. Or by the RF stage(s), if the first mixer is unusually robust as may indeed be the case with a 6SB7Y, 6BA7, 6K8 or Ediswan Mazda 6C9.

When taking measurements with close tone spacings, the signal sources used must have very low phase noise otherwise performance will be masked by reciprocal mixing mush. Also, the attenuators must be truly linear, and must not interact with each other or with the combiner network. This writer uses an identical pair of Marconi TF144H/4S signal generators, each of which uses a high level unsynthesized 5763/QV03-12 oscillator without any subsequent amplification, followed by entirely resistive output padding. To combine the two generator outputs into a single 50Ω feed to the receiver under test, an Olektron B-HJ-302U dual directional coupler is used. This provides good inter-generator isolation without excess transmission loss in either leg. Tubular 10dB fixed BNC pads are fitted directly to each port of the coupler to provide a further 20dB of inter-generator isolation, and to provide a reasonably accurate 50Ω source impedance for the receiver under test. The path from each individual generator thus has 10 + 6 + 10 = 26dB loss in the line. On the end of this chain is an 8-way Raven 50Ω multicoupler unit. This uses a pair of FET devices to provide sufficient overall gain, together with very high IP and low noise figure. This test system provides accurate and repeatable results down to 5kHz tone spacing. Intercept points are measurable to beyond +20dBm as and when (rarely) necessary.

An even better way ahead, especially when measuring with very close tone spacing indeed, is to use high level crystal oscillators to provide the tones. The crystals need to be tightly specified, of exemplary quality, and designed especially for this job. You should expect to pay very good money for a suitable crystal. The precision oscillator circuits are usually bipolar designs containing a special amplitude feedback mechanism which is quite separate from the oscillator RF circuit. This approach reduces the output problems due to limiting noise and waveform distortion. The output voltage is usually derived from the current flowing through the crystal slice.

A supporting rationale for the choice of 10m as the basis for critical third order intercept point measurements of valve HF receivers is as follows.

1. Nearly all valve radios deliberately operate with restricted gain on the LF bands where good strong signal handling was understood to be needed, but have high gain on the HF bands where ultimate sensitivity was considered to matter far more. Thus the 10m intercept performance will be the most severe case. Yet it is fully representative if the receiver is to be used as a tunable IF with a VHF down-converter, or if it is to be used with a good single-band 10m beam for contest use at a time of high MUF.

2. Some sets have so much front end selectivity on the LF bands that they get extra intermodulation performance for free just by attenuating one of the fundamental tones in the RF tuning system. This prevents the furthest distant tone from being amplified fully, even with offsets as small as ±10/20kHz. Radios with such superb pre-selectors include the Drake R4C and the Racal RA17L/RA117. Intermodulation performance on the LF bands with these receivers is determined at least as much by the tuned circuits as by the active stages, especially when the tone spacing much exceeds 50kHz. For this reason, measurements on these bands have less value as an engineering diagnostic technique than test results obtained at the higher frequencies of coverage.

In bench testing on 10m with 20kHz tone spacing, extremely variable 3IP test results are recorded from model to model. Over-gainy sets with poorly designed mixers may be as bad as -30dBm. Carefully designed valve sets with deliberately low overall gain even at HF, but correct distribution throughout the block diagram, can do much better.

The star performer for third order intercept point in the writer's collection is the Collins R-390A, which gives +5dBm. The best of the single conversion 2RF + multiple IF class that this writer has measured is the Eddystone S940C, which gives -17dBm. This result is all the more remarkable considering that this set also gives excellent sensitivity.

The lemon giving the -30dBm result is the National HRO-MX. The main problem is its inadequate mixer, even though the level of injection from the local oscillator is quite high. This radio is noteworthy for having a very transparent mixer and front end. This causes a very high level of local oscillator breakout from the antenna port on the higher frequencies. This was a well known problem with this model in the days of Band I television broadcasting. To make things worse from an intermodulation viewpoint, the National HRO maintains high levels of gain right down to the LF bands. Perhaps in the spectrally uncontaminated days when it was designed, the smaller number of signals made outright sensitivity a necessary design target even at low frequencies.

In the event of problems being indicated by a poor third order intercept measurement, this writer would suggest moving to the 1dB compression technique to try to find a solution. This is because the average receiver does not take kindly to having scope probes attached to tuned anodes or grids to look at the waveforms. Additionally, the use of a spectrum analyser as a diagnostic tool is made difficult by the fact that its own intermodulation performance may well be worse than your faulty receiver. Unless of course, the radio is severely overdriven to produce a high level of intermodulation products, or is very seriously defective. The technique of trapping-out the two strong signals to artificially increase measurement dynamic range of the spectrum analyser is definitely not recommended. This approach is likely to reduce measurement accuracy by introducing unwanted slopes and unknown losses. In any case, it may not save the analyser front end from expensive damage if things go even slightly wrong.

14.5 1dB Compression Point

This is a single-tone strong signal performance parameter. It is the RF input level at which the receiver indicates the signal strength to be 1dB weaker than it actually is. The problem is caused by the onset of signal crushing somewhere in the receiver architecture. The 1dB compression point is easy to measure, and with caution it can be used to solve problems found when measuring third order intercept point in a two tone intermodulation test. In an ideal system, the 1dB compression point has a value typically 17dB below the third order intercept point. However, the exact relationship depends on curvature characteristics of the system under test and can vary a few dB either side without being particularly indicative of linearity problems. In the case of HF receivers, noise and skirt limitations can be the major cause of significant deviation from the 17dB figure.

In an idealised receiver, all stages would compress at the same antenna input drive level. In the same way, all stages should start to intermodulate simultaneously. In the case of semiconductor receivers these ideals can be approached fairly closely, but the early stages of valve receivers tend to over-gain to a greater or lesser degree depending on the basic design quality. When tuned to the adjacent channel of a single strong signal so that the receiver gets full severity without the benefit of any AGC, signal crushing will occur first in the stage preceding the IF filtering. Thus in the case of a Collins 75A-4, the second mixer will compress at a much lower input level than that necessary to compress any other stage.

As the strong signal is then detuned so that it falls down the skirt of the first IF response but stays within the RF bandwidth, the first mixer will become the stage that crushes first. This will occur at an input level lower than the adjacent channel measurement by a factor equal to the conversion gain of the second mixer plus the skirt rejection of the first IF. Sometimes, the second mixer will not ever compress under these conditions because the first mixer will be quite unable to deliver enough power through the first IF selectivity skirt to achieve it, however much input drive is applied to the antenna socket.

As the signal is further detuned so that it starts to fall down the skirt of the RF selectivity, then the RF stage(s) will become the part of the receiver most susceptible to compression, though at a fairly high level depending on the absolute value and distribution of the RF selectivity.

A non-intrusive method of detecting the onset of compression involves the use of a small, electrically insulated 3 turn coupling link held in loose proximity to the anode coil of the stage concerned, say an inch away from the end of the coil former. With the coupling link cabled to a spectrum analyser, it is easy to discern the onset of crushing. The 1dB compression point will be where the coupling link detects a rise of only 9dB when the input level step is actually 10dB, as set by exact adjustment of the signal generator attenuator. The arrangement used by Marconi on their older signal generators for instance the TF144 series, which have separate 1db and 10dB stepped attenuators, makes it very easy to identify the 1dB compression point. Experimentally moving the link a little further from the anode coil when the receiver is thought to be overloaded, will ensure that the analyser does not compress before the stage being measured. This simple check will confirm that the measured test result is truly due to receiver performance limitations, and not due to problems with the measurement system.

An excellent example of a valve radio with textbook 1dB compression performance is a Collins 75A-4 when modified by replacement of the 6BA7 first mixer by an E88CC twin triode, and replacement of the 6BA7 second mixer by a heavily padded 7360 beam deflection valve. The block diagram is then: 1) 6DC6 pentode front end; 2) E88CC single-triode (sic) first mixer injected with 5V p-p to generate a 1.5MHz to 2.5MHz tracked & tuned first IF; 3) 9dB resistive attenuator; 4) 7360 beam deflection second mixer injected with 11V p-p local oscillator which differentially feeds selectable 455kHz mechanical filters. Note that the 2nd LO has to be beefed-up with an EF95 at V15 to achieve the 7360 injection figure quoted. This particular receiver has been further modified to include a 2.1kHz IF tailing mechanical filter, and is exceptionally pleasant in use, especially under SSB contest conditions. On 20m, with a strong signal only 5kHz off tune, the input level needs to be -24dBm before the second mixer compresses by 1dB. The third order intercept point here measures -29dBm. With a strong signal 100kHz off tune, the input level needs to be -18dBm before the first mixer compresses by 1dB. At this tone spacing, the third order intercept point measures -7dBm. When 500kHz off tune, the input level needs to be -2dBm before the RF amplifier compresses by 1dB, corresponding to a measurement of +14dBm for the third order intercept point. It may be that even this performance is not all this superb radio could achieve, given further tweaks to its gain distribution. As supporting information, this radio has an RF selectivity system based on two tuned circuits (one either side of the single RF amplifier valve), and a first IF selectivity system comprising one top-capacity coupled double tuned circuit. The selectivity characteristics on 20m are as follows, measured using a TF144H/4S signal source and a loosely coupled 3-turn link feeding an HP141T spectrum analyser system.

REJECTION	RF B/W (total)	1st IF B/W (total)
3dB	100kHz	40kHz
6dB	175kHz	60kHz
10dB	300kHz	80kHz
20dB	550kHz	140kHz
40dB	2MHz	300kHz

14.6 Mains Current

A useful measurement is the AC current drawn from the mains during normal operation. This is usually in the range 200mA to 600mA for 230V radios, and of course double this for 110V sets. It is a useful figure to hold on file, to help the diagnosis of future faults before they develop into anything really threatening to the mains transformer.

Because of the potential seriousness of an equipment fire, it may be wise to consider the construction of an over-current trip box which cuts the mains supply to your radio in the event of current demand exceeding 150% of the normal figure.

An earth leakage trip may also be worthwhile. However, certain radios may trip out even when operating normally, unless the mains input capacitors are completely disconnected from the chassis. The Murphy B40 and Marconi Atalanta in particular, have very high value mains input decoupling capacitors. You are advised not to wear headphones unless the chassis is well earthed!

Mains fuses cannot be relied on to protect your radio from disaster. Their principal job is to protect the mains power network from faults occurring in your radio. They achieve this objective by breaking at about three times their rated current, on a continuous overload. By the same token, mains fuses inside your radio will certainly not protect it against faults present in the line cord, and may not even protect it against faults present within the radio's own mains RF decoupling network.

15. EMC Considerations

15.1 Emissions

Radios with valves often had very high levels of local oscillator injection to the first mixer, causing high levels of unwanted conducted emission into the antenna feeder. Often, this conducted emission will be 455kHz above the operating frequency. On the higher frequency bands, the front end valves will provide little reverse isolation of the fundamental or harmonic frequencies of the local oscillator, and the RF tuned circuits will do little to stop the local oscillator getting into the anode of the preceding stage. The National HRO is especially bad in this regard. The antenna will be reasonably efficient at the LO frequency, since its resonance is only some 1½% removed from the radio's operating frequency at 30MHz. This obviously assumes that the antenna is correctly adjusted. The net result can be a high level radiated emission from the antenna structure occurring at the local oscillator fundamental frequency, and/or at harmonics thereof. The fundamental can cause problems to other users of the frequency band you yourself are operating on. The third harmonic can fall into ITU-R broadcasting Band II, in Europe at least. The situation can be worsened appreciably if any RF screening plates are loose, or if any valvecans are missing.

Unwanted local oscillator voltage can be conducted out of the mains port, and can be at a high level in the case of radios that do not have integral mains filters. This is unlikely to cause a significant problem unless several of your radios are operated from a common mains supply. A proper mains distribution filter would then be helpful.

15.2 Immunity

In the domestic EMC environment, both CENELEC and ETSI say that the ambient unwanted field strength may reach 3V/m. Worse still, this "real world" level is increasing at the time of writing. Certain things can be done to help old receivers work as well now as they did when they were new, in the quieter radio spectrum that existed at that time.

Additional immunity from unwanted common mode RF injection into the antenna port may often be obtained by more intelligent use of the antenna terminals, which on the older radios tended to be more comprehensively provided than on today's models. Wherever possible, use a balanced feeder. Best of all, some radios had provision for a fully screened **and** balanced antenna input feeder, for example the Hammarlund SP600JX-6 and Collins R-390A. To make optimum use of the Collins R-390/R-390A input arrangement, put an electrically noisy hair drier right next to your feeder but spaced several feet from the radio itself, then adjust the balance trimmers for minimum noise output on the ranges you actually use, with the antennas you actually use. If you do not have a noisy hairdryer, then a nearby PC or SMPU may do this job just as well!

The addition of a mains low-pass filter may improve performance on the LF bands. If you include a varistor surge limiter too, here you have a cheap way of protecting your valuable mains transformer and preventing destruction of the rectifier cathode in the event of gross surges on the mains supply. Some radios had inbuilt mains filters, for instance the Collins R-390/R-390A and the Hallicrafters S36. [Pic073] This is viewed by the writer as an indicator of unusual design excellence.

16. Some Interesting Equipment

16.1 Marine Radios: the RCA AR8516L & Marconi Atalanta NS702 type 2207C.

These are ship's Class B HF receivers, operating from 110VDC floating supplies. Both designs have 240VAC to 110VDC transformer/rectifier subassemblies mounted inside the cabinet on the rear panel. The RCA AR8516L power supply runs whenever the set is plugged into the mains, something that modern day owners (and insurers?) need to be wary of. The radio front panel ON/OFF switches are in the DC line between the power supply and the radio. When the radio is switched OFF, the reservoir voltage rises to a very high value… which is dumped into the radio the moment it is switched ON. The Marconi Atalanta power supply does the job properly, with double-pole mains switching and fusing. Better still, this set has a proper mains input EMC filter, albeit one which connects no less than 2μF from live to chassis. To avoid electric shock from the Marconi Atalanta chassis if the mains earth should become disconnected, this writer has fitted modern 4.7nF/440VAC ceramic capacitors instead. On both sets, the heaters are wired in series - fed with smoothed DC on the RCA, and raw AC on the Marconi.

Considering the Marconi Atalanta first of all, the chassis metalwork is directly connected to the negative 110VDC pole. This entire chassis assembly is insulated from the cabinet and front panel by large amounts of thick Tufnol and SRBP. The Marconi Atalanta has a QS75/20 neon LO HT regulator and a crude Marconi 85kHz single-pole neutralized mechanical filter described in the handbook as a "magnetostrictive resonator", of bandwidth 100Hz. It works very well on CW. To provide good tracking, this radio uses harmonic mixing on its top range. The RF valve sockets are very accessible, which makes a nice change from most HF receivers! Six small metal rectifiers are used for noise limiting, AGC generation and desensitization in a complicated circuit that works well. All of these devices have been replaced by 1N4148s in the writer's radio, to promote long term reliability. There is no built in S-meter, but there is a well contrived external metering box that can be used in conjunction with three 12-way Jones sockets to speed diagnosis in the event of a fault. The Marconi Atalanta has a proper thermionic double-diode balanced product detector, which is used in single-ended mode as an envelope detector for AM. Being a marine radio, the BFO covers USB only. The dial plate calibrations stop at 28MHz, although frequency coverage does extend some way above this. There is a very useful fine tuning control which shifts the 2nd LO. A mechanical bandspread arrangement is provided for the marine bands. The component quality is excellent.

These sets were so well designed and built that some remained in service into the 21st century. (The writer found one on a coaster in Hong Kong during 2001, switched on and working.) Now looking at the RCA AR8516L, this design uses mighty roller chains to connect the band change shaft to two complicated parallel wafer switch banks running from front to rear of the chassis. The original plastic tongue & groove couplers had grossly excessive slop, and on the writer's example have now been replaced by solid metal types. Large idler pulleys are fitted. On the whole, this is not a successful mechanical arrangement. The chassis is connected directly to earth, not to the negative supply pole. The power supply is quickly demountable from the cabinet, which certainly makes it easy to work on. All circuitry is fully isolated from chassis except for a single 33kΩ pull-down resistor. There is no neon HT regulator. All valves are unusual (in Europe) B7G and B9A types with 600mA heaters, for example 3BE6, 3AL5, 12CU5, 5U8 and 7AU7. There is only a single RF amplifier, and this is fitted with low-Q coils. Although the RCA AR8516L has a high first IF, its predecessor the RCA AR88D manages an embarrassingly superior level of image rejection on 10m. The RCA AR8516L has a 455kHz second IF, with an excellent Collins 3.1kHz tubular mechanical SSB filter. Twin VFOs are used. Despite two adjustable BFO frequencies (centered on 45kHz and 455kHz) there is no product detector, and USB speech copy is correspondingly poor.

Of course being a marine set, LSB reception is in any case not available. The mixing scheme is strange in the extreme and the scale linearity is poor, though actual readout accuracy is better than on the

Marconi Atlanta. Numerous ganged variable capacitors are used in the RCA AR8516L, actually more than on any other HF receiver yet seen by this writer. The AGC and noise limiter circuits are rather rudimentary and would not be especially effective against the high static levels found in the tropics. The AR8516L design originated in the USA but it was developed and manufactured only in England. Despite being intended for use as a ship's main receiver, cheap TV-grade resistors & capacitors were used throughout. These components will no doubt have quickly proved unreliable.

There are two massive electrical design flaws. Each is a simple decade resistance error. This writer suspects that the American prototype radios worked fine, but the job of transferring production to the English RCA factory in Sunbury-on-Thames was botched due to misreading some multiplier rings. After fitting two "correct" resistors, performance improved from very miserable to fully adequate. There are two serious mechanical design flaws in the RCA AR8516L as well. Changing the dial bulbs requires a fairly major strip down. Even worse, numerous small brass screws are used to hold the major mechanical subassemblies onto the chassis plate. These screws shear all too easily, and repair can be very difficult. The RCA AR8516L gained a very bad reputation, and these radios were quickly withdrawn from service. The production batch was dumped onto the ham market at very low prices, and survivors are justifiably rare. Of interest, the successor radio (RCA type CRM-R6A) did away with the final 45kHz CW IF system. An additional fixed 825kHz IF was introduced on some ranges, and a 500Hz Collins J-type mechanical IF filter could be specified, to restore the CW performance. Sadly, the extremely bad IF rejection lived on in the RCA CRM-R6A. Only 30dB is achieved by these radios on the 10m band. As with the RCA AR8516L, this is entirely due to poor materials and shoddy electrical design in the front end.

16.2 Turrets: the Murphy B40D.

This design has an unusually well engineered and extremely accessible turret tuner, combining good accessibility with individual screening of each coil. [Pic121] This set is mechanically quite different from anything else, clearly the thinking of a very fresh design team. The RF unit, AF/PSU unit, front panel and mainframe all employ cast Aluminium structures. [Pic120] The tuning gang is a ceramic shaft type mounted at the very top of the RF unit. It is operated via two grease-packed gearboxes with a long interconnecting chain drive between them. Each tuning range covers two complete revolutions of the drum, which rises and falls on a mighty threaded leadscrew. Construction is modular. [Pic123] Early variants had fragile mains transformers, and used the rare Philips B8G (like loctal) series of valves. The CV versions originally fitted to these sets were all metal clad, except for the hot-running types.

The original B40 had no band indicator other than the illumination bulb for the range in use. This particular radio is a B40D, the final production variant. It has miniature valves throughout. [Pic124] There is an external local oscillator trimmer for use on the higher frequencies. A high slope EF91/CV4014 front end is fitted, complete with an "anti cross-mod" front panel control to adjust the RF amplifier curvature to minimize unwanted distortion products. The crystal filter is a simple 2-pole lattice type, and appears to be a copy of the design found in the earlier Eddystone B34/S358X. The AGC operates in feed-forward mode to the audio amplifier, as well as in conventional negative feedback mode to the RF and IF strips. Frequency stability was sufficient to allow these sets to handle teleprinter traffic under battle conditions on board warships. In fact, better stability than the older Marconi B28/CR100 was a prime design requirement for the Murphy B40.

Despite being made almost entirely of Aluminium, this is one of the heaviest of all valve receivers. Variants included the B41 LF version and the 62B SRE receiver. The special transistorized FAZ SSB adaptor used with the B40 was made by McMichael. This device had electronic discriminator feedback to compensate for LO drift. The result was that all voices were reproduced at a constant average pitch, though there was slow drift during any pauses. The resultant audio sounds rather bizarre. The simplified equivalent to the Murphy B40 which was used in small ships was the CAW/CAZ Tx/Rx/PSU radio rack. Each assembly included a Murphy AP100335 or later AP100375 (SSB) receiver, or the inferior equivalent types made by Rees-Mace, who were actually Pye. The Murphy & Rees-Mace designs were functionally identical to each other, but totally different in detail. The Murphy AP100335 was conventional compared with the Murphy B40 but it was still unusual, and very compact. [Pic122]

16.3 Wafer Switches: the AME 7G1680BA.

This French dual conversion receiver uses grossly oversize wavechange and IF bandwidth wafers. It dates from 1952. There is a chassis heater, which is automatically switched into circuit whenever the radio power switch is set to OFF. All wiring is completely bare and uninsulated. This is a highly unusual and visually elegant arrangement, but prone to shorts if anything is disturbed or if there are any solder splashes. The entire design is extremely spacious, and the set is correspondingly large and heavy. These features indicate that the 7G1680BA was intended for operation in high humidity environments such as French Indo-China, or in extreme cold. It would have been easily serviceable in the field, which is a truly excellent design feature. Audio output comes from a modest single 6V6, despite which the HT chokes (plural), mains transformer and output transformer are all enormous. Two 5Y3GTs are employed, with the usual octal neon.

This set uses the obscure French MG series of metal-clad valves including the rare 6H8MG dual-diode pentode, for which a 6B8 can be substituted. The MGs are similar to metallized GT octals, but rather taller. Visseaux broke the rules by releasing some ordinary metallized GT octals as MG valves near the end of production. Whichever construction was used, the average MG valve is just as tall as a standard shouldered glass envelope. A 6AF7 magic eye is fitted. This is similar to type EM34 but with a 300mA heater, an over-size bakelite base, and a different angular relationship between the target display and the valve spigot keyway. There are two scarce 6E8MG triode-heptode valves in this chassis. Metallized types X61M or ECH35 in GT envelopes can be used as direct substitutes, and are far more readily available. The fact that these are triode-hexodes makes no difference to the operation of the radio. The HT fuse is an ordinary MES bulb, which glows dimly during normal operation and thus acts as a useful quick visual indicator of general HT health. Whether it would fail as reliably under fault conditions as a full-size HT fuse seems most unlikely, and is regarded by the writer as a significant safety compromise.

The IFTs are plug-in octal pot core types encased in resin. They had all drifted HF beyond the available adjustment range by the time this set was acquired. This fault was compensated for (rather than corrected) by the systematic addition of low value ballasting capacitors throughout the IF strip rather than by rewinding all pot the cores, which would have been impractical. The L:C ratios are thus nowadays slightly low on this radio, but not enough to significantly change the overall IF performance. The final IF has a crystal filter at 80kHz, which is extremely sharp. The two tuning gangs appear to be Gold plated! They are carried on huge gravity-cast Aluminium subchasses which are supported on fiberglass insulating bearers. Perspex is used for the coil formers, valve sockets and switch wafers. The dialdrive requires very many turns to get from end to end on the scale. The gearbox is a surprisingly puny grease-packed worm drive affair with its endstops operating directly on the output shaft. Because of the enormous mechanical advantage, this has resulted in the worm wheel becoming damaged at some time. Very difficult repairs were needed. Pointer travel is controlled by a long leadscrew, which is very precise in operation but less than totally free from backlash. At least this arrangement avoids the need for string or wire to move the pointer. This set originally had an octal female socket as its mains chassis connector, necessitating dangerous male pins on the mains line cord. A 3-pin Bulgin professional male chassis connector is now fitted. The antenna patch panel has also been rebuilt to make use of standard connectors.

16.4 Restoration Techniques: the Marconi CR100/B28.

This specimen was the last Marconi B28 ever released by the RN, being kindly donated to the writer by the HMS Collingwood museum on the express condition that it be properly rebuilt for future generations to see its performance. [Pic079] Some 20,000 of these sets were manufactured, starting in 1941. Construction was difficult because of wartime conditions. The Marconi CR100s were built in Chelmsford by the local women and old men, while the younger men were away fighting the war. The RN B28 variants worked well at sea during World War II, although the glass octal valves used to jump out of their sockets on firing a full salvo! This set has been rebuilt using ceramic pillar standoffs paralleled by wire-ended capacitors, rather than re-using the original metal tubular capacitors. [Pic032] Each of these 1940s components had a 2BA earthing stud at its chassis end. Direct replacements for the original components are nowadays unobtainable. It was felt necessary to retain the original grounding points for all the decouplers, for the following reason. The restoration of this set was undertaken primarily to identify how it would have performed when new, to identify the truth or otherwise of the widespread rumor that Marconi CR100s were hopeless receivers that always drifted wildly at HF. This radio has been entirely rewired except inside the coil box, where the original yellow insulation was PVC or something similar. This was a high technology material during the war, and was fitted by Marconi to prevent tarnishing of the Silver plated wavechange contacts by Sulphur released from ordinary rubber insulation. The coil box wiring proved to be fine; in fact it required absolutely no attention at all. This rebuilt example now works very well. [Pic031] It does not drift too badly even on 10m, in fact about the same as a healthy National HRO-MX. The lack of any cover over the tuning gang is not too important as the cabinet is poorly ventilated. So the ingress of draughts & dust is not significant. The IF & detector strip is particularly praiseworthy as regards its response shape, audio SNR recovery and AGC action.

The ergonomics are however very poor. In particular, the fine tuning has some backlash due to the use of a simple and crude Jackson Brothers ball reduction drive. The overall result is that this set is not particularly pleasant to use. Maybe it would have been better when new. At least the kHz/revolution figure is quite low, which helps the situation. The S-meter and its driver valve replace the RIS circuitry originally built into this particular receiver. There was a drawing office error on the chassis layout or a constructional defect which resulted in the band change shaft not correctly lining up with the switch wafers. This problem appears to have been fixed only on late production versions. To enable deliveries to continue under wartime conditions, mid-production radios such as this example were given a split band change shaft with tensioning screws spread at intervals along its length. This allowed a sufficient degree of self-alignment! [Pic033]

This particular radio was built as a B28 variant for the RN. It has the D63 noise limiter option, complete with its toggle switch which lives inside the main cabinet. The limiter has an important but very simple electrical design error which is quite easy to identify and fix. After correcting this design fault, the limiting action is distinctly better than on most other wartime radios. The BFO circuitry was crammed inside a tightly fitting metal cover. Typically for a Marconi CR100, the BFO cover originally fitted to this radio is missing. [Pic035] No doubt this is because of short circuits in the original rubber wiring. The original mode switch carried AGC and HT on the same SRBP wafer. This caused +5V of AGC standing bias due to the tiny amount of leakage. A twin-wafer ceramic switch is now fitted. The front wafer handles the HT distribution, and the rear the AGC. There is little clearance between the back of the rear wafer and the front of the oscillator box metalwork but it does all work well enough, and is a great improvement on the original arrangement. [Pic034] This Marconi CR100 cabinet has been drilled to accept the rare post-war AP63993 companion CW transmitter. Unfortunately this subassembly is no longer fitted. They were built for use by the 1950s UK civil defence network when training for a nuclear war. These little transmitters were very effective. A special small-envelope shouldered glass STC 6V6G was specified, but most survivors nowadays have an ordinary 6V6GT.

16.5 Gearboxes: the Collins R-390.

This design is the most complicated of them all, the fore-runner to the far more numerous R-390A made by Collins and others. The R-390 design was by Collins, and early examples were made by them in their own factory. This late model was manufactured by Motorola for Collins (ie not directly for the US government). It was incomplete and in scrap condition when acquired. This particular Motorola R-390 was delivered against procurement contract 14214-PH-51 as serial 4705. These receivers run very hot because the thirsty HT system is fully regulated by a pair of beefy 6082s. Worse still, there are lots of other valves on both the top and bottom of the chassis, without much room for ventilation. For these reasons, reliability is not of the finest. The tuning is rather heavy because of all the mechanical transmission, but everything does work well enough when in good order. The Collins 307E-1 4:1 geared reduction knob shown here is a modification fitted by a previous owner. It was originally a costly option for the Collins 75A-4 ham radio receiver. The rear panel fitted tools are missing from this Motorola R-390, as usual.

The weakest part of the electrical design was the calibrator, which was not only complicated, but also very prone to producing the wrong output frequencies. Early sets had badly designed kHz shaft endstops which could all too easily be over-ridden. Production of the Collins & Motorola R-390 receivers was so expensive that a special cost reduction exercise was instigated. This resulted in the simpler Collins R-390A. Both the 26Z5W and the 3TF7/TJ311M01 barretter proved to be rather fragile in service with the original Collins R-390. Puzzlingly, both types were retained in the later Collins R-390A, where they continued to give just as much trouble. This particular radio has been modified to use a Croze 268-0025 barretter rather than an Amperite 3TF7 or TJ311M01. By rewiring the barretter socket to connect pins 1, 3 & 4 together, and pins 6, 7 & 9 together, all three of these barretter types work perfectly in this radio.

16.6 Permeability Tuning: the Collins R-390A.

This is a front end RF assembly made by Amelco. Late production subassemblies such as this one had ball bearings in each slot roller as well as in each cam follower. This gives lighter tuning than on early models such as the Collins seen behind it, which had plain slot bearings. The underside photo shows extensive earth strapping not found on early units. This was a production modification to reduce the quantity and level of spurii. The Collins R-390A was a simplified and updated version of their earlier R-390 for the US military. It had only one RF amplifier instead of two; no squelch; simplified audio filtering; an unregulated main HT system with electrolytic capacitors; pressed instead of cast chassis fittings; simplified mechanics & second LO; and mechanical filters instead of LC IFTs. The early winged emblem Collins mechanical filters are robust. Later round emblem ones work better but were more cheaply made, using foam (which nowadays will be rotting) to support the filter assembly inside its cylindrical can. These later filters are prone to irreparable failure under mechanical shock, and look certain to become a serious problem for radio collectors in the years to come. Replacement aftermarket types are now becoming available to the collector's market.

Despite being simpler and cheaper, the Collins R-390A was not really inferior to its predecessor. This represents a highly significant engineering achievement. Many manufacturers made this model. The complete list together with the estimated delivery quantities (originating from N5OFF to who go the writer's thanks) is: Collins 6185, Motorola 14202, Stewart-Warner 6587, EAC 11686, Capehart 4237, Amelco/TSC 3642, Capehart o/b/o Adler 5, Imperial Electronics/TSC 3976, EAC/Hammarlund 118, Dittmore-Freimuth 215, and Fowler 2. This last order was as late as 1984. Total production of complete R-390A radios was thus 50855. In addition, very many modules were manufactured as spares. The complete radio photographed here is Collins serial number 24 of order 14214-PH-51. This order was satisfied by a batch of Motorola R-390 equipments made for Collins, plus the very first batch of R-390A receivers from Collins' own factory in Cedar Rapids. This particular set is believed to be the twenty-fourth R-390A production model ever manufactured. It has received a very detailed restoration. Every one of the modules is original to this mainframe. Only the engraved front panel is taken from a late-production example. The original silk screened front panel is in fair condition and kept safely stored for posterity. This set has one non-standard mechanical filter, open-frame line and local audio output transformers, and a 6BE6 product detector. It is otherwise as built by Collins.

16.7 An Unusual Chassis Design: the RME Model 99.

The RME99 is a very rare radio, at least in the UK. Although rather corroded after many years of damp storage in a shed, this example is now once again fully functional. Note the cast Aluminium frame, onto which is screwed a flat tinplate chassis bed. There is no separate front panel because the radio chassis assembly slides into the case from the rear, in a reverse of the usual arrangement. All the markings, the meter and the glass are located on the front of the cabinet box. This unusual construction must have caused production of the RME99 to be rather expensive. A single RF stage is fitted. There are lots of loctal signal valves, plus an octal VR150/30 neon and a UX4 type 50 rectifier. The Iron components are far larger than normal for a set of this class. The main tuning dial hides behind the tiny window on the right. It carries a superb hand-marked scale, but the graduations are so small that reading the frequency is very difficult. The big dial is for amateur radio band spread. This set works very well indeed, and is a credit to its designers all those years ago.

16.8 Catacomb Tuning Racks: the National NC100XA.

This set represented a technological dead-end, and is a rare model in the UK. [Pic075] When acquired, this radio was very rusty, and it had been heavily modified by a previous owner. The highly unusual mechanical arrangement manages to combine generally bad chassis accessibility with a severe shortage of headroom for nearly all components mounted under the chassis apron. The topside is tidy enough, though. [Pic078] The RF tuned circuits are well isolated from each other, and the local oscillator breakout level was very low. These are very good features. The huge cast "catacomb" carriage has an integral rack which is moved from side to side by a spring-loaded pinion mounted on the band change shaft, in an arrangement pioneered by the National NC81X. Two pictures show the carriage positions when selecting the LF and HF bands respectively. [Pic076, Pic077] The RF/IF design features are generally derived from those of National's HRO. In this case, the early style filter with its demountable crystal is used with the later metal octal series of valves. (Why?) There is only one RF amplifier, a low performance 6K7. An infinite-impedance detector is used for generating AGC. The lack of any cover over the tuning gang is not too serious as the cabinet is poorly ventilated, reducing the ingress of dust and draughts. The gang itself is a conventional fore-&-aft type. Adjusting the dialdrive endstops is extremely tedious. A clever mechanical arrangement lengthens or shortens the tuning scale pointer to indicate the range in use. The PSU/audio area of this chassis is not standard because it was rebuilt by a previous owner. This radio originally required 110VAC mains and an external loudspeaker transformer. It will now accept 115VAC or 230VAC, and an onboard output transformer is fitted. This receiver was adopted by the US military as type RAO. Many variants were made, not all of them by National.

16.9 The Best of the Wartime Sets: the RCA AR88D.

This American radio has a superb, anti-vibration mounted RF unit that used edge of technology materials when first introduced. To satisfy the design intent of producing a truly excellent receiver, the variable capacitors were housed in a metal box inside another metal box. This reduced the ingress of draughts, and lowered the level of LO fed into the antenna. The overall RF construction improves the short & medium term LO frequency stability, and makes multi-receiver working practical without an excessive number of spurious signals. The RF trimmer capacitors are airspaced tubular types fitted with ceramic guides at the top and bottom. All valve sockets and switch wafers are ceramic. The RF coil formers are polystyrene. The only real weaknesses in this design were the wax in the IFTs which proved to be hygroscopic, and a definite tendency to eat HT Iron components. This problem is usually caused by leakage in either of the two grid capacitors feeding the fragile 6K6GT output pentode. A "back bias" HT system is used. This sometimes suffered from problems with burned out dropper resistors. The big decoupling capacitor block can weep oil from its base seals, which can make a horrible sticky mess on the bottom cover plate. [Pic148]

This particular radio is a fairly early example, though it's not so early as to have an all-white main tuning disc. Those RCA AR88Ds kept in service with the UK armed forces after World War II had the front panel machined flat, the Chromium-plated horizontal strips removed, and the legending engraved. This was to allow easier decontamination by Fuller's Earth in the event of fallout occurring during a nuclear war. Some of these long-serving sets were rewired in PVC by McMichael, and would probably represent the best of the many survivors. One batch of unused RCA AR88Ds was released new and crated in the 1960s. These sets sold for over £80, but they would be no more reliable than all the other originals in the longer term. Variants included diversity models, and the RCA CR91A which had front-panel control of IF crystal phasing.

There was also the excellent Canadian-manufactured RCA AR88LF version which had a 735kHz IF, different rear panel arrangements, British threads, a simpler output stage based on the more robust 6V6GT beam tetrode, and screened rear panel connections. This variant had no top band coverage, which made it relatively unpopular with radio amateurs. Most RCA AR88Ds were originally supplied without the 5mA S-meter. This was partly because of a temporary shortage of meter movements and partly because in fixed installations, the S-meter was often mounted externally on the operator's diversity control panel. The remarkable feature of all variants is their stability and sensitivity on 10m, together with a sensible rate of tuning and a clean oscillator note on all bands. The image ratio of the writer's RCA AR88D is remarkable at 42dB on 10m - and the AR88LF does even better because of its higher IF. When inspecting one of these radios with a view to purchase it is worth checking the gear teeth carefully because severe gearbox wear is not unknown.

16.10 British Post-war AR88 Equivalent: the GEC BRT400D.

This radio was made by the General Electric Company (GEC) of England, which is not related to the General Electric (GE) company of the USA. This set used no fewer than four different valve bases: octal, B8G (similar to loctal), B4 and B7G. [Pic103] Later variants such as the GEC BRT400K and BRT402KN used B9A and B7G valve types whilst keeping the B4 neon and a couple of octals. [Pic105] What a mixture! It is strange that GEC chose not to rationalize the valve choices more thoroughly when performing the design update. This particular radio has the BRT403 calibrator fitted. The GEC BRT400D was broadly equivalent to the RCA AR88LF & AR88D combined, but GEC fitted a calibrator as well and separate controls for RF gain and IF gain. In comparison, not one of the RCA AR88 family was ever given a calibrator, and the RF and IF gain controls were always combined. The underside photo shows the inaccessibility of the RF unit which cannot be dismantled since all its partitioning bulkheads are riveted into position. [Pic104]

The chassis design is very heavy indeed, but it is not stiff enough to withstand even moderate mishandling. One reason is that the central chassis sections are not riveted or screwed into position, they are only soft-soldered. Worse still, the (genuine) table cabinet uses cast side plates which are very heavy but contribute no stiffness to the structure. On the GEC BRT400D, only the LO gets the benefit of ceramic switch wafers, though all the RF & IF valve sockets are made of this material. These sets run very hot indeed because of the unusual active smoothing arrangements. The writer's BRT400D and BRT400K are both modified to include extractor fans to keep the operating temperature under control. [Pic146] Two beefy KT81 beam tetrodes are used - one for the audio output, the other for the active HT hum compensator. [Pic106] The HT current drawn by a healthy GEC BRT400D is no less than 167mA. This is almost double the requirement of many similar sets. The mains tap should be set as high as possible to reduce the risk of burn-ups. The later GEC BRT400K used cheaper plastic valve sockets and smaller (and less reliable) EL84 pentodes, but the radio still drew as much HT current as before. [Pic107] The chief vulnerability is flash-overs in the IFTs caused by poor design, a fault that is extremely difficult to repair. All GEC BRT400s have an anode bend AGC detector which works well, and there is a particularly praiseworthy AM signal detector and audio system. [Pic108] Even on longwave, both RF amplifiers are in circuit although on this band, the RF tuned circuits are staggered to prevent them from taking over the job of determining the overall receiver bandwidth.

These features make GEC BRT400s extremely suitable for broadcast reception. The pointer travels on a stranded steel wire. On very early sets (identifiable by lack of front panel handles and dial lock mechanism), the dialwire passed around pulleys at the corners of the run. Later sets such as the GEC BRT400D used cheaper and simpler pressed brass guides instead. Each range dial strip is individually lit. The dial register is backlit by a bulb which also generally illuminates the interior of the set. Yet more bulbs are fitted to the dial vernier and the meter, making ten in all - plus two spares kept in threads pressed into the top of the gang cover. Is this is a record number of bulbs for an HF receiver? Most GEC BRT400s were installed in BBC or DWS stations, but this one was originally sold to the CAA. In general, GEC BRT400s are found well cooked and in poor condition. Nevertheless, service lives of 40 years are known. This indicates the toughness of the model, and the excellence of its components. Moral: the Brits could make decent HF receivers when they really tried.

16.11 Rare and Complicated: the McMurdo DST100.

This very strange receiver uses many American or Canadian chassis parts in its construction. It is a double-superhet constructed on two chasses. These have to be unwired from each other before complete removal of either unit from the cabinet is possible: there is no connector. All five top, bottom, side and rear plates are removable, to leave the chasses and front panel in position supported only by a steel skeleton frame. There is variable RF reaction, preset IF reaction and an infinite impedance signal detector. The seven IFTs are all plug-in octal types. Unusually for a wartime British radio, a tone control is fitted. There are no fewer than three tuning controls, all mechanically interconnected. This set has two meters, neither of which works as a conventional S-Meter! The front panel RF trimmer adjusts the mixer grid, not the aerial circuit. This set is very large and heavy, despite which it needs an external HT and filament power supply and an external speaker & transformer.

These features made the McMurdo DST100 an unpopular choice with radio amateurs. The front end valve is an Ediswan Mazda VP41 with a 4V heater, which is fed from 6.3V through a dropper resistor. The VP41 was the best of the RF variable-μ pentodes available at the time of design (1938), giving this receiver a Noise Figure of 8dB at 30MHz. In fact the VP41 was so good that it continued to be promoted for new designs until December 1948 - see the Ediswan advert in Wireless World of that month. All other valves in the McMurdo DST100 are standard 6.3V international octal types. The RF valves are mounted upside-down beneath the chassis. The lack of any cover over the tuning gang is not significant as this large component is hidden away below the RF chassis in a very cool and sheltered location. There are seven turret-tuned ranges covering 50kHz to 30MHz with no gaps. On the lowest range, no fewer than twelve 110kHz IF coils are operational, giving remarkable selectivity. Over the various ranges, three different conversion schemes are used.

General accessibility is very good, and the quality of circuitry design is truly exceptional. The only real design weakness is the second LO, which could have been crystal controlled but wasn't. These radios were made in a factory on a big farm near Whitby in Yorkshire. Although initially designed for the Army, most of the 1000 or so McMurdo DST100s produced were actually used in RN shore stations. They were made by made by McMurdo and RAP. The DST100 is demanding, even tiresome to use on all bands - not least because the dial calibrations are very challenging to read. On the positive side, this radio is certainly capable of excellent results when receiving a weak signal with slow keying. The RN used them alongside National HRO receivers, which proved a good combination for finding the important signals quickly and then reading them to a high level of accuracy.

16.12 Fire Hazard: the Hammarlund SP600JX-6.

Radios of this type should be treated with deep suspicion unless all the original Sprague Black Tubular capacitors have been replaced, and unless the winding/chassis insulation of the HT choke has been checked carefully. Both of these common faults have been known to cause fires inside Hammarlund SP600s. Removal of the RF unit on this radio is very difficult, and the turret stator contacts are impossible even to inspect without prior removal of most biscuits from the drum. The ceramic biscuits are not individually screened, but on the other hand they are extremely well made. The variable capacitor has a fragile ceramic shaft. The radio is dual conversion on the HF ranges, and frequency coverage extends beyond 50MHz. A 5R4G is used as the rectifier, which is highly unusual if not unique in this class of equipment. The Hammarlund SP600JX-6 radios did not stay in active service long because of their incendiary tendencies. Many of them were quickly made available to American amateurs for use on MARS USA/Vietnam communication links. The on-air performance is generally good, other than suffering premature overload problems due the excessive RF/IF gain caused by all the many 6BA6s and 6BE6s. There were numerous production variants including at least one VLF type, and the Hammarlund SP600 model remained in production for over two decades from 1951 to 1972. This example is the relatively common US Navy SP600JX-6 type R-274B/FRR, built to JAN specifications.

16.13 Styling: the Hallicrafters Super Skyrider SX28.

This clever wartime set switches an RF amplifier out of circuit on the ranges where it is not needed, has two independent AGC systems, a proper Lamb IF noise silencer, and hot running Class-A push-pull audio. A high slope front end valve is fitted on the MF and HF ranges, and there is band spread on the HF amateur frequencies of the day. For all this complexity, there is no neon regulator for the local oscillator HT supply. This set is more cheaply constructed than the RCA AR88D and much inferior as regards drift and image rejection at 30MHz. The Hallicrafters SX28 would have been far better with proper draughtproof top, front and bottom screening covers over the RF unit, low-loss coil former materials, ceramic switch wafers and airspace trimmers - all of which the RCA AR88D has. The Hallicrafters SX28 uses a 6SA7 heptode as its local oscillator valve, surely a bizarre choice for a multi-range superhet. Why not a simple 6J5 triode instead? Maybe they had a shed full of them. The main and bandspread dial pointer lengths are controlled by the wavechange switch, and images of the pointers are optically projected onto the tuning scales to show the range in use. The design of the coil box is extremely unusual, and elegant. The coils and trimmers are carried on individually removable bent metal bulkheads, making servicing easier than any comparable radio yet seen by this writer. The best repair technique is to pull out the bandchange shaft, swing the RF sideplates out of the way and then remove the bulkheads one after another until all are sitting on the bench. Then do the necessary repairs, and reassemble everything in reverse sequence.

These radios were much used by the US armed forces, and were very common in airfields all around the globe for a long time after World War II because frequency coverage extends to 43MHz. This particular example was built in the summer of 1943 as US Navy type AN-GRR-RCF-1. Intended for use on 25/60Hz mains, it has a huge mains transformer which runs fairly cool. The only real design fault with the Hallicrafters SX28 is an inclination to develop modulation rise in the IF strip when receiving a huge Medium Wave signal. The later and more cheaply manufactured Hallicrafters SX28A used much smaller RF coils, with a 6AB7 (instead of type 6SK7) as the second RF amplifier to compensate for the higher tuned circuit losses. This arrangement made for an even simpler coil box, but it worsened what was already the least good feature of the original design: the basic RF performance. Interestingly, the Hallicrafters SX28A uses significantly less brass than the original SX28. This reflects the severe shortage of Copper experienced by the USA during 1942 & 1943.

16.14 Overkill for SSB: the Hoffman CV-157.

This ISB adaptor was initially intended for use with the Collins R-390, but is equally usable with the later Collins R-390A. Both of these receivers provide a 455kHz IF output. The Hoffman CV-157 is very large and heavy. It contains no fewer than 44 valves, almost half of which are double-section types. There is motorized AFC, and the sideband filters are physically huge. In the days when this was made and for many years afterwards, it was conventional to operate the radio with a much wider IF bandwidth than would be considered acceptable today. This was necessary for the AFC to work properly, and in particular to provide sufficient bandwidth for the multiplexed teleprinter systems to work correctly. Each sideband filter is therefore 6kHz wide. It is important to understand that the Hoffman CV-157 was primarily designed for handling machine radio traffic, not voice. This equipment is well made, reliable, and nowadays rarely seen.

16.15 Collectability: the Eddystone S940C.

There is no doubt that valve Eddystones of all types are good investments by the standards of this hobby. This is the S940C, which was designed to use up Eddystone's stock of old subassemblies and components. Early examples had metal knob skirts, and a slightly different dial plate. The mains transformer is over-size, and produces a considerable excess of HT voltage. For this reason a 5Z4G rectifier is fitted here, rather than the meaty GZ34 which was also listed. This radio was quite well specified, and is understandably popular with collectors. It has push-pull audio, a cascode ECC189 front end, and Eddystone's standard 6BE6 product detector. Weak points in the design are: a) burnt-out voltage splitting bias resistors for the ECC189; b) pulling effects due to AGC being applied to the mixer (remove AGC from the ECH81 for an instant and substantial performance improvement on the higher frequency ranges); c) the poor dynamic range of the 6BE6 heptode product detector; d) the lack of any cover over the tuning gang; and e) the lack of squareness to the IF strip response when working in SSB mode.

Eddystones of this and earlier periods are full of poor quality TV-grade passive components which will need to be replaced en masse during restoration. The mechanical design is based on excellent castings, but the overall performance is let down by cheap materials, inadequate grounding, and small RF coils which cause mediocre image rejection on 10m. The meter has the usual Eddystone nonsense calibration, scaled 0 to 10. On the rear panel, the fragile connection terminals stand proud with no mechanical protection whatsoever. Because this is quite a heavy radio, these terminals are usually found well crunched on the Eddystone S940Cs that come up for sale. The feel of the tuning is excellent in keeping with this company's tradition, and the receiver RF performance is well up to the job. Makes a good heirloom!

16.16 Heavily Screened: the Eddystone S880/2.

This novel design of radio has 1MHz ranges and elaborate screening for the various oscillators in order to reduce LO breakout to extremely low levels. Alternate 1MHz ranges tune in opposite directions, which is extremely confusing! It is also unfortunate that the tuning action is very stiff due to the extreme complexity of its permeability tuning mechanism. Rather than using cams and followers, this set uses four leadscrew pillar jacks to raise and lower each corner of a single large platform carrying many ferrite tuning cores. Each RF coil has variable winding pitch along the length of its former. This approach must have been very difficult to manufacture, but it certainly represents a very elegant solution to the challenge of permeability tuning. Construction is modular. The front end is Eddystone's standard ECC189 circuit, with its attendant problem of burning out the 100kΩ voltage splitting bias resistors. Both mixers are EF95s. Puzzlingly, the injection levels to these mixers are very different. The reason for this is far from obvious, and the handbook nowhere refers.

The VFO uses a precision Wingrove & Rogers variable capacitor, and is extremely stable and linear. The crystal oscillator bank uses 5840 high reliability wire-ended pentodes inside a screened metal box located inside another screened metal box. The power supply uses two neons, which is a unique arrangement among old radios in the writer's experience. The IF strip relies on quartz 500kHz twin-slice B7G filters which were inadequate compared with competing radios fitted with Collins mechanical filters, or those other radios using a 100kHz final IF. On the positive side, the Eddystone S880/2 has a proper product detector (albeit this company's suspect design using a 6BE6 heptode); AGC tailored for SSB; 50kHz/revolution main tuning; a separate electrical fine tuning vernier; and a switchable fixed or variable BFO. These are all features which make this radio feel fairly modern to operate. The front panel is a casting which can be unplugged from its cableforms, and then dropped from the mainframe to aid servicing. This set is extremely heavy due to its extensive use of thick brass plate, much of which is Silver plated. Not many Eddystone S880/2s were made. This model went into the merchant navy and into government service around the world. The even rarer S880/4 variant with slightly simplified circuitry and different ergonomics was bought only by GCHQ.

16.17 British Coilpack set: the Eddystone S358X/B34.

This wartime radio mounts its coilpacks "fore & aft" on top of the tuning gang just below the cast cabinet lid, right next to the EL32 power output valve. This is clearly not a good idea because access is needed through the top of the cabinet, and because LO thermal drift is a problem. In the days when the S358X was made, Eddystone seemed to use metal castings wherever they could, and this radio is very heavy as a result. The dialdrive is one of the best ever made, although there are no proper endstops. This set became notorious at sea for the high level of local oscillator fed into the ship's antenna. The problem was caused by downright bad earthing of the coilpack combined with the use of only a single RF amplifier valve. The position of the ship could all too easily be located by hostile direction finders homing in on the radiated LO emission. The Marconi CR100/B28 was hurried into service as its seagoing replacement while the Eddystone S358Xs were redeployed to RN shore stations around the world where LO leakage was less of a problem. The Eddystone meter is used for current testing the various stages by means of a front panel rotary switch. It can even be used as a crude signal strength meter by tuning for a dip in RF amplifier current when the AGC is operating.

This particular Eddystone S358X receiver was built as a B34 variant for the RN. It has the EA50 noise limiter option. It also has a 2-pole quartz lattice filter of 500Hz bandwidth, as indicated by the suffix X on its commercial S358 part number. The detector screening box is rather crowded, but this radio otherwise proved straightforward to restore to full working order. In use, the Eddystone S358X proves surprisingly convincing. Coilpacks B, C, D & E were supplied as standard with the radio. Additional coilpacks A, F, G, H, I & J were available to special order. These extended the coverage all the way from 30kHz to 35MHz, although the claimed capability was limited to 40kHz – 31MHz. There was an IF gap in the coverage, and only the central ranges can be read directly from the dial. All other ranges came with calibrated charts, rather like the National HRO. This surely made the Eddystone S358X a record holder among wartime communication receivers in having well over three decades of frequency coverage. Although the architecture is simple, the EF39/ECH35 RF strip works better than many American sets can manage - provided no pieces of valve metallization have fallen off - and the two-pole IF filter is far superior to the usual single crystal phasing filter. There is one small design problem. Even when the crystal filter is supposedly switched OFF, it still has a noticeable effect on the main 5kHz passband. The power supply for the Eddystone S358X is type S390B, mounted in a hefty external box. This uses a GZ32/5Z4G rectifier. Two totally different PSU variants exist. On both of them, the mains switch is the usual unreliable Royal Navy type found on Murphy B40s etc. The Eddystone S358X gets by with only 175V HT and the current drain is low, so this is an unusually cool running radio. No doubt in-service reliability will have been very good as a result.

16.18 Post-war Super Skyrider: the Hallicrafters SX62A.

This was really a super broadcast receiver rather than an out & out communications receiver, because it uses string rather than gears to operate the variable capacitor and has a rather high tuning rate. The Hallicrafters SX62A uses a conventional twin pentode 6AG5 RF strip with an eight-gang variable capacitor all the way up to broadcast Band II, which must surely be some kind of record! The mixer/oscillator is the obscure loctal twin-triode type 7F8. A 455kHz IF is used on the lower frequencies, and 10.7MHz is used at VHF. This receiver is single conversion on all ranges of coverage. It runs hot because of thirsty push-pull 6V6GT audio running in class-A. The lack of any cover over the tuning gang or any screening under the coilpack means that drift on Band II is always a problem. There is at least a neon HT regulator, which is a good feature. Unfortunately there is no AFC, tuning indicator or signal strength meter. So retuning on FM broadcast stations is a frequent necessity! The reproduction quality is truly excellent. The user handbook shows 7H7 and 7A4 loctals in the IF strip, but this particular radio was built with 6SG7 and 6J5 octals instead. There is a 240V/110V autotransformer mounted piggyback onto the mains transformer. This was fitted by the dealer when the set was sold new in Switzerland. Cost-cutting in the design is evidenced by the lack of any fuses. To make things worse, the mains filter capacitors are of the notorious Sprague BT type. These are very prone to crack, and develop serious leakage.

16.19 Last of the Line: the Drake R4C.

This famous design is a hybrid which uses valves for the signal stages and transistors for the ancillary circuitry. The performance of these sets is excellent but depends on expensive multipole plug-in crystal filters. As always with Drake, the ergonomics were unusual and moderately unpleasant. On most of these radios, the tuning feels rough and notchy due to the use of cheap plastic gears. The very last batch of Drake R4Cs used a geartrain partly of brass, which worked much better. This example is a mid-late production model, with 6EJ7 mixers. Earlier R4Cs had 6HS6 mixers, and the ability to select only one CW crystal filter instead of two. This situation is typical of Drake’s seemingly endless and rather messy variations in production build standard.

The design quality of the Drake R4C is very variable. The final mixer gave problems when the valve type was changed halfway through production. Rather than stay with the earlier 6HS6’s cathode LO injection arrangement, the 6EJ7 design was modified to use grid injection into an enormous impedance. This can allow lots of unwanted hum and noise onto the signal, especially if the chassis wiring is not well dressed in the vicinity of the valve socket. Unfortunately, many late Drake R4Cs do show this problem to a greater or lesser extent. Apart from this issue, the signal stages are well engineered. In contrast, the power supply is downright badly designed and very prone to burning its printed circuit board. Class A audio is used. This successfully avoids DC line fluctuations on speech peaks, a design subtlety evidently not understood by those who would have you fit a modern class-B audio chip instead. However, it has to be said that the (single) audio output transistor is mounted directly below the VFO, and the heat does cause slow thermal frequency drift. This problem could have been avoided by a using better physical layout. There was a hum problem on nearly all Drake R4Cs. This was caused by bad layout of the chassis metalwork and improperly thought-out cableform routing. Astonishingly, part of the reservoir AC current was routed through the audio PCB earth print! Only on the very last few radios, some additional thick wiring was used to route the reservoir AC hum current directly back to the rectifier anodes. The Drake R4C does not share its mixing configuration with any Drake transceiver except the rare, and much later solid state TR5. The systems engineering aspects are unusually well thought out, so that it is possible to configure a very comprehensive Drake station using the C-Line range of equipments and ancillaries. Taken all in all, the Drake R4C is a highly effective communications receiver, but not very pleasant to use.

16.20 The Most Famous Ham Receiver: the Collins 75A-4.

This radio was extremely expensive when new, being the same price in the UK as a contemporary Jaguar car. More than 5800 were manufactured. Plug-in B9A mechanical F455J filters provided the IF selectivity. The angular position of the PTO subchassis was ganged to the angular position of the BFO capacitor in such a way that simple front panel control of passband tuning was achieved. The coupling mechanism was a flexible bronze drive belt. This same technology was also used to raise and lower the combined preselector & 1st IF slug rack. A regenerative adjustable notch filter was fitted, and the set had an early twin-triode product detector. The design uses 6BA6s in the IF strip, with a high slope 6DC6 in the front end. This particular example has been modified to incorporate an E88CC frame-grid twin triode first mixer and a heavily padded 7360 beam deflection second mixer. An IF tailing filter has been added, clamped to the inside of one of the chassis apron sidewalls. The result is a considerable improvement on the original circuitry, which used two 6BA7 mixers and was more than somewhat inclined towards premature overload. There were many modifications made during the production life of the Collins 75A-4. The final build standard was reached at about serial 3700, though many earlier examples such as this one (serial 1287) have had all the important upgrades fitted over the years. Although impossible to quantify, the Collins 75A-4 has a very nice “high quality” feel when in operation and it is an unfatiguing set to operate for long periods.

16.21 A Competent HF Transceiver: the Collins KWM-2A.

This ex-RAF radio has the Collins 136B-2 four valve TRF noise blanker option, which was fed from an external VHF whip antenna. It also has the rare B&W 340-A notch filter accessory. Early winged emblem radios such as this one used hard-wired unencapsulated relays on the underside of the chassis. These gave regular trouble in service. This set has been retrofitted by the RAF with the enclosed plug-in relays found on later round emblem radios. The receiver section of this radio works very well indeed, despite most of the valves also performing transmitter functions. One significant criticism has to be the 6EB8 audio output stage, which was never notably stable despite many production modifications by Collins over the years. The Collins KWM-2A is generally hard on its valves because of inadequate ventilation, especially when mobile in sunshine with a high battery voltage. The 6AZ8 IF amplifiers can start to suffer grid emission problems, and this type is getting scarce nowadays. Initially, the 6AZ8 was made as a triode-pentode, but later production from GE used triode-beam-tetrode construction. There is no significant difference in performance in the Collins KWM-2A. Some of the 6U8As can also have problems.

Towards the end, Collins introduced a production change to the more robust type 6EA8 in the V13 position. The piggyback speaker and mains power supply unit fitted to this particular radio is the Collins model PM-2, which was intended for light duty work only. The original mains transformers were rather fragile, as is common in American equipment. This example has had a Gardners fitted by the RAF. It is of far higher quality than the original Chicago Standard Transformer Co item. The only operational irritation when using SSB mode, is the lack of an RIT control. In the days when Collins were the only SSB manufacturer, this feature would not have been needed because everyone else was also using Collins gear. None of it drifted much, and all of it drifted in the same direction in any case! The CW mode of operation is rather poor, as this radio gives a 1.5kHz receive frequency offset and there is no narrow filter.

This example was in scrap condition when acquired from RAF Cosford amateur radio club, and required a lengthy rebuild using many mechanical parts taken from an incomplete chassis that was being broken for parts. The radio forms part of a genuine Collins "KWM-2A Traveling Station". It is housed in a Samsonite model CC-2 fitted suitcase also containing the PM-2, a microphone, a morse key, a lightweight headset, and a wire antenna. There is a companion fitted suitcase containing a 4x 811A Collins type 30L-1 linear amplifier, with all the umbilical cables. This equipment is also ex-RAF, the whole lot having last been used operationally on Ascension Island during the Falkland Islands conflict in 1982. Carrying both suitcases together certainly makes your arms grow longer!

By the time the Collins KWM-2 was produced, the authorized dealers were well versed in the art of persuading purchasers to also buy a wide range of expensive ancillaries which increased the overall profit on the sale and helped build the brand in the marketplace. They sold Collins clocks, Collins pipe racks, Collins station control units, Collins ashtrays, Collins remote VFOs, the lot! How very American. The KWM-2A is a nice radio to use. This particular example runs even hotter than usual because all the optional modules fitted inside it not only consume extra HT & LT power, but also restrict the convection airflow out of the top of the cabinet. To avoid problems, a small external fan is nowadays positioned over the PA cage whenever this radio is being used.

16.22 Wadley Loop Implementation: the Racal RA17L, RA117 & RA218.

These equipments followed the original Racal RA17. The radios were now fitted with an ECC189 variable-µ cascode tuned (but not tracked to the dialplate) RF amplifier. The Racal RA17L used a multi-section broadband 1st IF filter, and a mechanically tuned (and tracked to the dialplate) 2nd IF arrangement. A low power EF91 audio amplifier is fitted. Early examples used a metal rectifier or germanium diode as the AGC clamping device MR8, but later models used a proper EA76 wire-ended thermionic diode. [Pic125] All members of the RA17/117 receiver family are electrically and mechanically unconventional. The circuit uses the Wadley loop principle to give a full set of overlapping 1000kHz ranges without a bank of individual conversion crystals. [Pic128] The design uses reliable high slope frame-grid E180F pentode mixers.

Unfortunately the design of the actual radio circuit is too simple. There are only two AGC-controlled valves: the ECC189 RF amplifier and the 6BA6 first 100kHz IF stage. The result is marginal AGC control range which quickly becomes inadequate if any of the signal valves are weak, the IF alignment is incorrect, or if any of the AGC decouplers go a bit leaky. The very late Racal RA17C-12 was given AGC on its second (and final) 100kHz IF stage. This improved the AGC range considerably though at the expense of modulation rise on strong AM signals. It was a better compromise overall, and made the radio more tolerant of small faults. The Racal RA17L components are divided between 2 large VFO modules, a large IF module also containing the BFO & noise limiter, a small calibrator module, and the massive gravity-cast Aluminium mainframe itself. [Pic129] Readout of frequency is presented on an excellent filmstrip scale.

The Racal RA117 variant had an additional stage of frequency conversion and an additional subchassis, to allow external control by an early synthesizer called a Racalator. The RA117 has a beefy 6AQ5 audio output stage, and some versions use standard US valve types throughout except for the E180F mixers. A Silicon full-wave rectifier is fitted in place of the thermionic valve used on most RA17 models. [Pic126] The Racal RA218 ISB adaptor seen here provides the final stage of frequency conversion down to 18kHz, at which frequency there is a pair of 3kHz wide LSB & USB filters implemented using pot-core inductors & capacitors. In addition to its primary function, the RA218 provides a useful fine tune vernier when used with a Racal RA117. Some aspects of the RA17L/RA117 and RA218 alignment sequences require patience, experience and good test equipment. The Racal RA117/RA218 combination works well when correctly set up. On the RA117, the VFO does drift a bit. This characteristic is very unlike the RA17L, which was notably stable.

The SSB and AM IF filtering shapes are reasonable, but Collins mechanical filters would undoubtedly have helped. For CW, the bandwidths are well chosen and the radio does not ring as much as most rivals. On all valved radios in the Racal family, it is essential to keep the bottom covers tightly fitted in order to avoid gross spurii at multiples of 1.000MHz. [Pic127] Even more interesting than the production designs, is the original Racal RA17 prototype. [Pic131] Development had been dogged with serious spurious response problems. This was eventually fixed by sawing the cast chassis in half with a bandsaw, and then bridging the gap with a large tufnol block to separate the RF earth current return paths. [Pic132, Pic133] Even the underside of the chassis mainframe needed drastic modification to reduce the spurii to an acceptable quantity and level. [Pic134]

16.23 Early VHF: the Hallicrafters S36/BC-787-B.

Although billed on its front panel as an “Ultra High Frequency” receiver, this radio covers only the VHF frequencies 28MHz to 144MHz in three switched ranges. The BC-787-B is the military variant of the Hallicrafters S36. This one dates from July 1944. Its forerunner, the Hallicrafters S27 was a very similar set which had played an important part in the development of military airborne navigation systems. The S36 was later developed into the S36A, which had permeability tuned IFTs and simplified antenna connections. The Hallicrafters S36 uses a single conversion 5.25MHz IF strip with a choice of two bandwidths, and is capable of demodulating CW, AM and FM signals. The power supply uses a 5U4G rectifier plus octal neon, and the audio is this manufacturer’s standard 6SL7GT & class-A 6V6GT thirsty push-pull arrangement. The IF system uses metal octal valves throughout.

The really interesting part of this radio is the RF unit, which is a substantial compartmentalized plated brass box containing the classic 956 front end, 955 local oscillator and 954 mixer acorn valve lineup. A puzzle is why the RF amplifier used a vari-μ valve, when no AGC was applied. It would seem that a 954 would have given somewhat better sensitivity. The tuning mechanism uses a conventional three section variable capacitor which is very well engineered. The rotor sections are insulated from each other, and from the chassis. The switching, valve socket arrangements, and general constructional techniques pioneered on this receiver set the industry standard for fifteen years. A proper mains input RF filter is fitted, always a sign of careful detail design. This radio is extremely heavy. It drifts but little, a tribute to sound mechanical and thermal design and the quality of components & workmanship employed in its construction. Unfortunately, the design is compromised by inadequate mains wiring which is just ordinary thinly insulated stuff lashed into the main loom. As was often the case with contemporary American designs, a fuse is fitted in one mains line and a single pole switch is in the other. This particular radio has some wear on the gearbox input bearings, indicative of very heavy usage. The audio is especially good. The Hallicrafters S36 is generally nice to use, having a very “solid” feeling to its controls.

16.24 For the Avro Lancaster Bomber: the RAF R1155A.

The radio was designed by Marconi, who made them in Chelmsford, Essex. The RAF R1155s were also manufactured by EKCO down the road in Southend-on-Sea, and later in the war at Aylesbury on the other side of London. [Pic085] Some 80000 were produced under wartime conditions, a quite remarkable achievement. This is a superb design which manages to cram more block diagram into its box than any other mobile radio of similar vintage except the Pye WS19. [Pic088] The cleverness of the R1155’s design extends well outside the radio, to include an extensive harness system connecting the companion RAF T1154 transmitter, a crew intercom and a highly elaborate direction-finding installation. This particular EKCO radio arrived in scrap condition.

Typical of an R1155 surviving into the 1990s, the DF equipment had been ripped out by a previous owner and a mains PSU and output stage fitted instead. The rebuild to sort out this mess involved the fitment of many new components, especially replacements for all the original ghastly three-in-one metal tubular decoupling capacitors. [Pic089] A 6V6GT output stage was later refitted to this chassis for convenience, and an external PSU/loudspeaker constructed. The RF and IF amplifier valves are KTW61s, as used in the CR100. There are three hard-to-find valves. Type MHLD6 is a 6R7G/DL63 fitted with an oversized triode section. Two of these are used in each radio. Type VR99A is an unmetallized ECH35, not to be confused with ordinary type VR99. One of each is used in the R1155. Type BL63 is an unusual double triode. All of these valves are octals. The HT supply needs to be fully floating, at about 220V. The BFO and local oscillator are unusually pure, with the result that this radio manages to sound like a fairly well sorted SSB design fitted with a product detector! The RF coil box design is especially praiseworthy, managing to be compact yet easily serviceable. [Pic087]

An unusual feature which is believed unique except for the later AWA A510 transceiver is that the BFO runs at half IF frequency. This was a fairly successful attempt to reduce the level of harmonic spurii. The RAF R1155 had a very complex production history. Numerous variants were developed. One of them allowed the extension of deployment to MTBs. These radios had steel cabinets in place of the original Aluminium, and different frequency coverage. Other variants incorporated special circuitry to reduce interference from jamming carriers. [Pic086] Later RAF R1155s were built with the greatly improved type 35 dialdrive. Some early equipments received this as a modification when in the RAF workshop for periodic overhaul. That is probably why this particular radio has one. A specific caution must be given regarding RAF type R1155M, which was a variant incorrectly manufactured with corrosive acid flux. These sets are very rare nowadays, and best avoided.

16.25 A Rare Prize: the PSEI Trophy-8.

This radio is a pre-war design with eight Tungsram non-BVA valves. It was designed and manufactured by one of the better British shortwave houses of the day. The writer’s example was probably built in 1938. It arrived in derelict condition, very scruffy and somewhat incomplete. [Pic051] Despite costing nothing, the writer values this receiver very highly because it is such an interesting design. Restoration is ongoing at the time of photography. [Pic049] These receivers were used at Bletchley Park alongside National HROs and McMurdo DST100s, so they certainly worked well enough when they were new! Coverage extends to 43MHz. SSB can just about be resolved on 20m, but the performance on 10m is hopeless because the tuning rate is no less than 5MHz per revolution of the tuning knob. In any case, there is no meaningful image rejection at these high frequencies. The front end RF amplifier is a low noise EF8 “silentode”, mounted on the CT8 base. Despite its EF moniker, this valve is not a pentode and actually has four grids. Two of them are aligned in a way that starves the screen grid of current, thus reducing the level of partition noise through the valve. The EF8 can thus be thought of as a variable-μ RF predecessor of the much later EF86 audio pentode. All other valves in this chassis are octal. The mixer is a large and thirsty 6TH8G, which is a re-based ACH1 fitted with a 6.3V heater. This valve is sometimes seen marked as 6TH8 rather than 6TH8G, even though the (metallized glass) envelope is exactly the same. The 6TH8G can be directly replaced by the much later ECH35/X61M to give an instant improvement in performance, at the cost of originality.

The front panel now has a modern brass-rimmed barometer glass over the dial, as the original Aluminium item was missing. Of course, the new barometer glass has an unwanted hole in the middle! All knobs are original, including the tuning knob which looks quite out of place on this chassis. [Pic050] The drive from the knob to the tuning mechanism is by Meccano chain, which has a lot of backlash. This may be a modification made by one of the owners, or it may be original. At least one other PSEI Trophy-8 used a rubber belt drive. The radio performance suffers from very poor RF grounding. To make things worse there is not a lot of IF decoupling, which was a frequent shortcoming in PSEI designs. Unfortunately, the 6TH8G mixer is not fully stable. This is believed due to the many grounding tags that are sandwiched between the paxolin valve sockets and the painted chassis pressing, without even the benefit of star washers. It seems likely that several of these local RF grounds are nowadays ineffective. This suspicion will be checked before long and acted on as necessary, to restore the original level of performance. It will be interesting to see how this old receiver shapes up. In its present state as shown here, this PSEI Trophy-8 functions reasonably well on the LF and MF bands. Shortly before restoration work commenced, this old radio saw service on the 50th anniversary D-Day net operated in the UK by the Barry Amateur Radio Society in South Wales. So it can't be too bad!

16.26 Ham Competitors: the Heathkit SB-300 and KW202.

These are a handsome pair of receivers. [Pic080] The Heathkit was an all-American kit design. This one was assembled in the UK by their subsidiary Daystrom Ltd, and arrived in excellent condition after being very carefully looked after by its previous owner. It has three crystal filters and one compactron in a layout which uses a conventional metal chassis to support two SRBP PCBs of mediocre quality. [Pic081] The VFO is excellent, allowing read-out to a genuine 1kHz. This assembly was supplied to Heathkit by TRW as a ready-built item. The component and wiring layout is excellent throughout the SB-300 chassis, and the component quality is satisfactory. [Pic082] The owner's handbook is spectacularly competent, as was always the case with this manufacturer. The Heathkit power supply is needlessly overcrowded, which is about the only mechanical shortcoming that seems worth mentioning. Proper CW facilities are provided, and there are three selectable AGC speeds. This radio now has a proper mains earth fitted to promote safety.

Although the Heathkit SB-300 has an antenna change-over switch, its isolation is highly suspect. Perhaps they would have done better to fit a higher quality component, or leave it out altogether to encourage the owner to do a proper job externally. The KW radio is British designed and built, using the nowadays fragile Kokusai mechanical filter. [Pic083] The iron components are of unusually good quality, as was typical of this manufacturer. KW made their own ECF82 VFO which worked well enough, although the read-out accuracy is not the finest. In standard form, the variable capacitor is totally exposed in the middle of this well ventilated and therefore draughty chassis. A great benefit in stability is achieved by fitting a simple plastic cover, as here. Miniature valves are used throughout. The mechanical assembly comprises a single large high quality FR4 PCB, onto which mounts a daughter board for the calibrator. [Pic084] The KW202 sports a transistorized notch filter and Q-multiplier, and the design also provides separate controls for RF and IF gain. Unfortunately, there is no proper CW IF filter.

A lot of work was needed on the PCB underside to repair track burns caused by botched modifications made over the years. The entire Copper surface is now lightly varnished with polyurethane, to improve mechanical integrity. As constructed, the KW202 had grossly excessive audio hum but after fixing two simple earth plane design errors, the performance became quite reasonable. For the amateur radio community, the quality of user documentation is very important. That provided by KW to support their receiver is barely adequate. Both of these amateur radio receivers work well on the LF bands, but the Heathkit has the edge on filtering and intermodulation performance. On the 15m & 10m bands, the Heathkit SB-300 moves decisively ahead of the KW202 because of the latter's overly-simple RF tuning arrangement which introduces very significant loss ahead of the RF amplifier valve on these high frequencies. Both of these receivers are quite rare in the UK but given a choice, the Heathkit SB-300 would be the better bet. What a pity the KW202 was not upgraded to use the greatly improved receiver architecture of the concurrent KW2000E transceiver.

16.27 Complex British Ham Set: the Eddystone EA12.

Eddystone implemented a Collins-style double superhet SSB receiver architecture in their EA12 model for the amateur bands. [Pic036] A tuneable first IF is fitted. This covers 1.1MHz to 1.7MHz, so that the entire 10m band can be covered as four separate 500kHz segments with 50kHz of overlap available at each end. The fixed second IF is low enough at only 100kHz to allow sufficient LC selectivity for SSB. There is a very effective variable frequency IF notch filter with a depth of 40dB, as well as a CW single crystal phasing filter which is only 50Hz wide at the -6dB points. There is even a CW audio note peaking filter, which is 200Hz wide at the -6dB points. Separate control of RF and IF gain is provided, and the AGC time constant is switchable. Eddystone's usual cascode ECC189 RF amplifier is used, with its attendant problem of burning out the voltage splitting bias resistors, in this case R6 & R7. The two mixers are both ECH81 heptodes, which were about the best of the multi-grid mixers. The Eddystone

EA12 was an expensive set, definitely in the "luxury" class and it is clear that they tried extremely hard. The design is well executed, being spacious and electrically competent though somewhat spoiled by the use of Eddystone's mean little RF coils. [Pic101] A 5" internal loudspeaker is provided.

Restoration work on this radio is underway at the time of photography, so a temporary protective plate of 1.6mm FR4 laminate material has been fitted over the loudspeaker aperture. [Pic099] Unfortunately, Eddystone's usual projecting rear panel terminals and inadequate mains connector are fitted. [Pic100] The dialdrive uses a logarithmic mechanical linearizer to give an approximately uniform frequency progression across the scale. [Pic097] A proper crystal calibrator is provided. The Eddystone EA12 was built with cheap TV-grade passive components made by the likes of Dubilier, Plessey and Hunts. These components have not lasted well, and a proper rebuild will require the replacement of a good handful of these original parts. [Pic098] The coils and transformers will normally be found in good condition, as they were constructed to a very high standard. The final IF achieves continuously variable bandwidth by physically repositioning one winding within each double-tuned IFT, to change the mutual inductance. This is a blatant copy of the Hammarlund Super-Pro SP200 IF design, and none the worse for that! Whilst being mechanically complicated, this approach does enable a truly symmetrical expansion of bandwidth.

One specific problem which appears common on this model is cracking of the S-meter acrylic window. The reason is unclear. The writer has two Eddystone EA12 receivers. One has had a replacement meter fitted recently, and the other has a small fracture in its original S-meter moulding. Needless to say replacement meters are nowadays very hard to find, although the Eddystone User Group has had a small batch made by Sifam. In practice, the Eddystone EA12 is a very satisfying receiver to use. The tuning is especially smooth. The AGC works quite well. SSB signals are resolved by Eddystone's usual rather inadequate 6BE6 product detector, which has very limited dynamic range. The only real criticisms are the selectivity which could be better for operating under crowded modern band conditions, and the VFO stability which is barely adequate for such a sharp IF response curve when operating in CW mode. Fortunately, there is at least a proper HT neon to reduce the drift caused by changes in mains line voltage.

16.28 Early and Very Competent: the National HRO-MX.

This wartime example was originally fitted with a plain non-illuminated Marion Electric 1mA meter because of a long-running shortage of parts at the factory, but the usual National S-meter is now fitted. The radio now has a larger than standard number of BFO tuning vanes, to allow easy copy of both USB and LSB speech signals over the swing of the BFO capacitor. The National HRO-MX came with 9 general coverage coilpacks, and there were 4 amateur band coilpacks available. This radio has all 13 of these factory coilpacks, plus various other home-constructed band spread packs to cover 160m, 15m and the WARC bands. The coilpacks are inserted into the front of the radio, which necessitates the main 4-section variable capacitor being mounted transversely across the chassis. To achieve this without using an edgewise tuning knob, a worm & wheel gearbox was used in this design. The nominal IF of a National HRO-MX is 455kHz, but the crystal in this particular radio resonates at 453kHz. The National PW dialdrive is thoroughly pleasant, but examples differ in the amount of torque required. This one is a little stiff. No proper endstops are provided, so care is needed at the ends of coverage. A fully configured National HRO was a very expensive set when new, costing more money than an RCA AR88 and a lot more than a Hallicrafters SX28. An external power supply is required.

This particular National HRO is operated with fully regulated HT and (DC) LT supplies. Users need to be careful of the rear panel output terminals, which carry HT and must be connected to the primary of a suitable external loudspeaker transformer at all times. Care is also needed around the antenna terminals, as HT is present on the S-Meter adjustment potentiometer which is mounted nearby. An additional warning applies when changing coilpacks. The HT must be switched OFF whenever this operation is performed. The National HRO has no conventional dial but in practice, this is no real disadvantage. The ergonomics are generally sound, and the single-crystal phasing filter is especially effective. The under-chassis layout is very neat indeed, and accessibility is good. Many examples such as this one, have been completely rebuilt with new components. The original waxed capacitors usually go very leaky and resistors drift high in value. All such components will need replacing. The original electrolytics dry out and lose value, but these can usually be left in position and used as anchor points for new wire-ended components as shown here.

Some National HROs had ventilation louvers cut into the cabinet sides. This example has none. The VFO becomes a little more stable if the lid is propped open about 1" during operation. Rack mounted models were available. The circuit is fairly conventional except for the use of a pentode mixer, which proves rather transparent. Even though two RF amplifier valves are used, there is a relatively high level of local oscillator leakage into the antenna and the RF strip gives a poor level of intermodulation suppression. The National HRO had a very long production career. The earliest examples used UX-based 2V battery valves, a diecast gearbox cover, and were available with or without an IF filter that used a plug-in crystal. The 1943 version was adopted as receiver type R106 by the British Army, as here. It uses UX-based 6V valves. There is a bent metal gearbox cover, and the IF filter contains a wire-ended crystal. Later wartime versions used metal octal valves. These radios are noticeably lighter in weight, and perform rather less well than the original UX versions. Differences exist between the UX and octal coilpacks. They look very similar if not identical, so care is needed to collect together a properly matching set. Very late models of the National HRO included a noise limiter and SSB facilities. The model even lived into the transistor age as the HRO-500, which was the last of this distinguished line.

16.29 Very Late German Design: the Telefunken E127KW/4.

For Telefunken, this is a surprisingly conventional receiver. [Pic109] It is fitted with a superb and rather beautiful 2-speed rainbow tuning dial. [Pic116] Unusually bright scale illumination is provided. [Pic115] Military versions exist, and these have a heavy protective metal cage in front of the main panel. Two speed tuning is provided, selected by a push/pull tuning knob. The front panel legends are extremely puzzling, being symbols only on this example. The manufacturing date of this low-mileage radio is about October 1969, which is very late for an all-valve HF receiver.

The chassis topside shows few surprises, with six large cylindrical tuning cans on the IF unit and a row of ganged capacitors for the RF tuning. [Pic110] One unfamiliar component is a large adjustably-tapped power resistor mounted above the mains transformer. [Pic111] The chassis underside has large screens over the RF and IF subchasses, and an open power supply. [Pic114] The RF unit mounts in the centre of the chassis, and is very conventional. Two EF85 RF amplifiers are fitted, with band pass coupling between them. An ECH81 gives single conversion to a 525kHz IF, so a five-gang variable capacitor is fitted. [Pic112] The IF unit is a conventional LC design with distributed crystal filtering, which gives a reasonably good shape factor. [Pic113] Audio output is from a conventional EL84 circuit which will be okay unless the valve starts to develop grid emission or gas problems, which this type is very inclined towards. The overall performance of the Telefunken E127KW/4 is certainly good: a 100dB RF increase above 2μV PD at 10MHz gives only 2dB rise in audio. This particular radio is mounted in a large TRA9/4 table cabinet, together with three ancillary units. These are a TG 455/2 printer adaptor; an SG 455/2 display unit; and an AD 455 antenna diversity unit. This sort of equipment configuration would have suited installations in embassies or large press agencies the world over.

16.30 Compact Post-war VHF: the Eddystone S770R/1.

This handsome and compact set has useful AM and FM facilities, and a BFO is provided. [Pic090] It is very heavy, a typical Eddystone job based on substantial castings. This example was used for HF/VHF surveillance by the RN over a long period, until superseded by the much later Watkins Johnson receivers. The design has a turret tuner with individual cast segments which pick up on a frame-grid pentode RF/mixer/LO strip. [Pic093] This was very high technology for the date, in the case of this example November 1954. [Pic096] Unfortunately, the use of a 6AK5 front end valve is a clear design error because this high-slope valve gets the full amount of AGC. The result is that under strong signal conditions it tries to perform the entire gain reduction task all on its own. The RF amplifier valve V1 almost shuts off completely before the row of 6BA6s in the 5.2MHz IF strip even starts to back off from maximum gain! Changing to a TungSol 6AJ5 in the V1 position improves the AGC performance dramatically. (These valves are variable-mu, unlike 6AJ5s from certain other manufacturers.)

The restoration of this radio proved to be a lengthy task, as it started from a large pile of scrap parts. There was no audio unit, and the IF strip had been butchered. Even at the best of times, the Eddystone S770R/1 is a very difficult set to work on. Access to components is poor, and they are the usual low quality items found in British domestic radios of this period. [Pic092] The chassis construction is modular. After much consideration of the risks and the effort required, the entire radio was dismantled to module level. The modules were pooled with those in the spares pile, and the best set of subchasses collected together for restoration. Each of the selected modules was then repaired to component level. In the end, the receiver was rebuilt from first principles. By good fortune, it worked fine as soon as power was applied. [Pic094] This was especially pleasing as the modules were originally of incompatible build standards. Some components had to be moved to adjacent modules to accommodate design changes made during the production lifetime. The audio unit came from a scrap Eddystone S770U. This uses the same metal subchassis as the S770R/1, but the output stage is a far superior design using a proper phase splitter instead of a self-balancing arrangement. [Pic095]

Due to the absence of a full set of original rear panel terminal lugs, the decision was taken to use ordinary modern 4mm pillars instead. An HT fuse was fitted as a safety precaution, and this is clearly visible in the photographs. It is surprising that this expensive receiver never had one fitted originally. The HT current of 125mA must be considered quite reasonable as this is a complicated VHF set with push-pull audio. The little 5Z4G rectifier sweats a bit though, because it is working at the very limit of its rated capability! The overall result is a radio which is really an Eddystone hybrid. The key reason for all this work was to find out if the dreadful reputation of the Eddystone S770R is deserved. These sets are widely reckoned to be extremely deaf, and more than somewhat unstable as regards the LO operating frequency. At the end of its long rebuild, this radio fully achieves its handbook performance figures. It is sensitive and reasonably stable, and turns out to be a very pleasant set to use. Its dialdrive is especially smooth. The IF bandwidth is a little too narrow for smooth copy of Band II broadcast signals, though.

16.31 Mobile Military HF Receiver: the British Army R209 Mk2.

This is a small but very heavy fully sealed HF portable/mobile receiver which was made in thousands for the British Army during the 1950s. [Pic066] It is a very effective single conversion design, with AM and FM facilities. The IF is 460kHz. The antenna can be a short aperiodic whip, or a much larger resonant structure located at the far end of a low impedance feeder system. An integral loudspeaker is provided, covered by a screw-down hatch when not required. This particular specimen is still regularly used outdoors in the UK climate, for which functional waterproofing is considered important. For this reason, its sealing is checked regularly and the desiccator gets dried out at the same time. [Pic008] A non-synchronous 12V WICO type 12NS vibrator originally provided the HT voltage.

The British Army R209 was intended for negative earth applications but would also function correctly from a positive earth supply. The mechanical vibrator in this example was subsequently replaced by an Antique Automobile Radio Inc type 2015N solid-state item. [Pic147] This proved a totally straightforward swap, giving much lower levels of mechanical buzz and electrical hash. Unfortunately the new vibrator forces a negative earth polarity onto the R209. For this reason and to improve safety in the event of a fault, the R209 front panel fuse has now been moved from the negative 12V supply line to the positive. Current drain is about 1.2A with either type of vibrator, increasing when the bulbs are switched on. B7G battery valves from the Dxx91 series are used, with the audio output coming from a DF91/DAF91 paraphase push-pull pair. On the face of it this sounds sensible enough, but inspection of the Ia/Vg curves shows that a DF91 is not even vaguely similar to the pentode section of a DAF91. For a start, the DF91 is a variable-μ valve, whereas the DAF91 is straight!

Getting the push-pull balance correct is one of the reasons for the complexity of the audio output circuit. It is frequently necessary to select the output DF91 (V9) to achieve smooth audio, because the circuit relies on mutual conductance from its control grid to its screen grid - which is not a controlled parameter. An indirectly heated EF92 is used as the single RF amplifier, to give good signal handling.

This feeds a DK91 heptode mixer which is injected by a DF91 local oscillator. Quite why the mixer was not type 6BE6 is a bit of a puzzle. Maybe not enough LO drive would have been available. There is a QS75/20 neon HT regulator for the LO. A lightly limited Travis FM detector is used, which is an obscure type of differential slope detector working between two tuned circuits peaked at ±10kHz with respect to the IF. This circuit proves surprisingly effective, especially considering this Mk2 version of the British Army R209 had reduced IF gain compared with the original design. The Noise Figure at 15MHz measures 10.5dB, which is easily good enough.

Construction is modular. [Pic117] Individual modules have metal screening cans, and are quickly removable from the mainframe for servicing. [Pic118] The largest module is the RF unit, which lives in a corner of the chassis to allow easy access. [Pic119] The upper limit of frequency coverage is 20MHz. The manufacturer of this particular set is probably MEL. The design process had proved so troublesome that the development programme ended up being led by MOD directly, rather than by any of the usual contractors. These radios were kept in front line service with the British Army until the arrival of the Clansman equipment. Even afterwards, many R209s continued to be used by units of the Territorial Army. In practice, this radio is surprisingly nice to use, although the tuning rate is a little high above 15MHz.

16.32 Very Australian: the AWA CR-6A & CR-6B.

In the late 1950s, times were hard in Australia. The government resented having to import expensive 51J-4 radios from Collins and RA17s from Racal. Despite its relatively small population size, the land area of Australia is huge at almost 8,000,000sqkm and the coastline no less than 26,000km long. This required a lot of LF & HF radios to ensure safety in the air and at sea. In response to this obvious sales opportunity, AWA introduced the extremely pretty CR-6A for general coverage over 2-30MHz, and its sister the CR-6B to cover the long wave 200-540kHz plus general coverage over 2-25MHz. Geography and climate considerations led to a chassis design which was very open, to give good ventilation and also to ease the work of the field service engineer who may well be working under difficult conditions. In this respect, these two receivers are similar to the (gigantic) AME 7G1680BA, which was designed for use in French Indo-China.

The AWA CR-6A & CR-6B are dual conversion radios with IFs of 1.8MHz and 100kHz. A proper modern twin-triode product detector was fitted. The RF unit used a variable capacitor with ceramic shaft, just like the Murphy B40 - which is a great idea until the radio gets dropped! The entire RF assembly was however quickly demountable so that it would have been practical to fit a pre-aligned service replacement module without too much bother. [Pic137] The RF architecture was conventional in using a single EF85 RF amplifier ahead of two ECH81 heptode mixers. Silicon OA202 diodes are used for AGC, noise limiter and detection functions. This was advanced thinking for 1958, and avoided all the problems of cathode poisoning seen so often with EB91s and their like in other radios. The HT rectifier is a Silicon bridge, another step away from tradition. Where the AWA radio broke new ground was that the idea of service-replaceable modules was extended to include the 100kHz 2nd IF strip. A block filter module containing 750Hz, 1.5kHz, 3kHz & 6kHz bandwidths was provided. [Pic138, Pic140] This unit included all five coils and the selectivity switch, the whole lot mounted on a neat little metal subchassis. Repairs and realignment of the 2nd IF module could be left to the base workshop, which surely made the job of the field engineer a lot easier. The 2nd IF gain came from a row of 6BA6s and a 6AU6 after the block filter, with only a single tuned circuit directly in front of the detector to reduce the noise bandwidth. Audio output comes from a 6AQ5, which will do the job just fine.

The underside of the chassis is unusually neat, and fitted with top quality Mullard polyester capacitors that can still be trusted to do the job properly even in 2011. [Pic139] The AWA CR-6A and CR-6B receivers could contain an optional 6-way crystal oscillator unit for fixed-frequency use. [Pic136] The only real disappointment is the 1st IF, which could have been tracked & tuned but wasn’t, no doubt due to cost constraints. The lucky writer has an example of each of these two receivers. [Pic135] His CR-6B has the multi-channel unit fitted, whereas the CR-6A has the proper table cabinet and is in generally better condition. Work is currently underway to construct the most useful hybrid. Neither radio has been powered-up in the UK as yet. Very likely these are the only CR-6A/B radios here.

16.33 Better Than Expected: KW's Last Gasp, the KW2000E Transceiver.

KW had clung to the inadequate KW2000B for too long, and British radio amateurs had grown weary of its limitations. Its replacement, the KW2000E showed stark contrasts in its design and was not manufactured for very long, probably starting in 1974 and ending in 1975. [Pic141] The wound components were excellent, especially the mains transformer in its separate box. WARNING: the umbilical cable connecting this PSU to its radio is dangerous, with up to 1kV (off load) **and** raw mains **and** transistor DC supplies all being carried through the same multicore cable with its tiny 20-way Painton connector, the metal shell of which is fully floating. [Pic144] Worse still, there is no separate earthing cable to bond the two units together in the event of a fault in the umbilical. In addition, the KW2000E HT reservoir is run beyond its 900V rating when off load, and the bridge rectifier uses only four BY238 devices… each rated at a mere 1500V.

On the positive side, the headline news is the use of a proper RF amplifier circuit using a 12BZ6 and an ECC85 triode first mixer. Better still, the receiver antenna input coils are properly switched, unlike the daft arrangement used on earlier models. Frequency coverage is in 500kHz segments, up from 200kHz on the KW2000B. The mixing scheme is dual-conversion as before. The 455kHz Kokusai mechanical filter is exactly as fitted to the KW2000B; these things are okay until the encapsulation foam goes rotten inside. [Pic142] The writer keeps Collins mechanical filters for fitment when the time is right. Following the filter, there are a couple of 6BA6s feeding the single-triode product detector. Audio output comes from KW's usual ECL82 circuit, which is well up to the job. The VFO heater gets a stabilised DC supply for the first time, and proper RIT & TIT facilities are fitted. The HT neon fitted to earlier models gives way to a 150V zener diode on this model, but an additional 22µF/250V decoupler is needed on this line to clean up the VFO note properly. The VOX circuitry works very well indeed, but not until diodes have been fitted across each relay coil to stop the contacts welding together due to back-emf!

This particular radio is very low mileage and arrived with its full compliment of original Brimar valves, most of these being Russian or made by RFT in East Germany. The construction uses only one small PCB, mostly relying instead on a conventional chassis with numerous solder-buckets supported in mid-air by a bunch of component wire tails. [Pic143] The writer likes this style of construction very much because it is easy to work on and reliable. Having said that, the VFO is very difficult to access because it is overly compact. A plastic cover over the VFO variable capacitor greatly reduces frequency drift, and is a simple modification. [Pic145] The KW2000E could so easily have formed the basis of an improved KW202 stand-alone receiver, but it never happened. Perhaps not surprisingly, the documentation supporting the KW2000E is inadequate. Large chunks of it are illegible, and there are errors. In this respect, the contrast with Heathkit, Collins and the various Japanese companies is very telling. In the end, KW got bought by Decca and the KW2000E soon faded into obscurity. It was too little, too late and far too expensive compared with the wonderful new Yaesu FT101.

17. Glossary

Some useful materials are described below, together with alternative names used in some territories, where known. The writer strongly recommends you to study the safety notes provided with each chemical that you intend to use, as in some cases the information provided here might be incomplete, misleading or even incorrect. There may be legal requirements applicable in some territories, covering for example acquisition, licensed usage, handling precautions, storage, and disposal, access by pets and children, and maximum storage lifetime. All chemicals need to be correctly labeled. Some of the product names used in this book may be registered as trademarks. You may wish to check before purchase, to ensure you are being offered the "real thing" and not an inferior substitute.

Araldite: Epoxy resin adhesive made by Vantico AG. The adhesive is supplied as a twin-pack comprising equal measures of base adhesive resin, and oxidizing hardener. These components must me mixed thoroughly before application. "Hard" and "Rapid" grades are available. In reality, these have setting times which are best described as extremely slow (days), and slow (hours) respectively. The actual setting time is very dependent on temperature. Araldite has excellent insulating properties, and can be used as a potting agent. Non-hazardous in use, but very inclined to create a sticky mess if mishandled.

Bostik: Multi-purpose adhesive made by the Bostik company. A heavy petrochemical base is used to support a plastic adhesive which bonds slowly on contact. This solvent is extremely flammable. Can be used as a small gap filler. This adhesive sets very quickly and is transparent, which can be useful for dialdrives & scaleplates.

EP90: Extreme pressure lubricant of SAE90 viscosity rating. Widely available as a specialized lubricant for hypoid automotive, agricultural and commercial vehicle rear axles. Most types are mineral-based, but fully or partly synthetic versions exist such as Syntrans and Syntrax. The EP90 lubricants have good "stay put" properties, and are very useful on radio dialdrives and gearboxes.

Evostik: Impact (contact) adhesive originally made by Evode Ltd, nowadays made by Bostik. A heavy petrochemical base is used to support a rubber adhesive which bonds quickly on contact. This solvent is extremely flammable. Can be used as a small gap filler as well as an adhesive. This adhesive sets very quickly.

Fluxite: An acid grease flux for use when soldering a chassis or other large steel assemblies. Corrosive. Excess flux needs to be washed off after use. The writer uses methylated spirit to do this job.

Goddard's Silver Dip: A domestic chemical sold for maintaining Silver finishes. Usually applied sparingly, using a pad of cotton wool or a paper kitchen towel.

Harpic: A toilet cleaner liquid applied with a "duck" shaped plastic bottle. Corrosive and highly conductive. Excess needs to be washed off after use. Works well for cleaning valve metallization.

Helicoil: Metal thread repair piecepart, having both an internal (female) thread and an external (male) thread. Allows usage of an oversize tapped hole to accommodate the original screw. Fitted in position with a special insertion tool.

Iso-Propyl Alcohol: IPA. This is a general purpose organic solvent which is not too harsh, and generally does not attack colour rings on resistors. It is considered safe to use, though flammable. Leaves a very unpleasant smell. Dissolves hammer-finish paint, though slowly. Iso-Propyl Alcohol is generally considered to be the successor to Carbon tetra-Chloride, which was banned in the UK a few years ago due to safety concerns.

Jenolite: Ferropro. This is a rust passivation agent based on Phosphoric acid. Hazardous to use, so wear gloves and goggles. Start by wire-brushing or sanding the loose rust away, so that the metal surface is as clean as possible. Wash the radio and also yourself thoroughly afterwards. This material converts rust to a black phosphate which can be over-painted. A variant of this material is Kurust, which appears to combine a rust pacification agent with a grey paint primer.

Jizer: This is a derivative of paraffin which is intended for use as a de-greasing agent. Water-soluble, so can be removed by washing after initial application with a stiff brush. A similar chemical available in the UK is called Gunk. This is black, and a lot more oily. It is even better than Jizer for removing extremely dirty old grease and congealed oil. B40 and other chain-drive owners might find this stuff especially useful.

Kapton: This is a polyimide film tape, available with and without a rubberized self adhesive backing. The most useful size is a 1"-wide reel with adhesive on one side. This is an excellent insulator, and extremely resistant to puncturing by sharp objects. Very useful for covering IFT holes to prevent the ingress of dirt onto beehive trimmers. Can be used to pack-out a knob which is loose on its shaft.

Dimensionally very stable with time. Excellent high temperature rating. Kapton is an expensive material.

Kilopoise 0868S: A specialized super-viscosity lubricant made by Rocol, comprising a silicone lubricating base thickened with soap and loaded with silica. Useful for lubricating balldrives. This material is extremely sticky, and very difficult to remove after application. Somewhat inclined to creep away from the point of application. Incompatible with mineral oils and greases, all traces of which must be removed before applying 0868S. Non hazardous to use, but very inclined to create a sticky mess if mishandled.

Kwikfyl: A specialized wax crayon stick which is available in a wide range of colours. Useful for filling the engraved characters found on panels, escutcheons, bezels and knobs. Applied with a candle, any excess material being removed with a rag immediately. Non hazardous.

Loctite: A range of thread locking compounds made by Henkel. They are available in a range of strengths and temperature-withstanding capabilities. Some grades are designed to be releasable, other types are intended to give a (very) permanent fastening.

Methylated Spirit: Meths, wood alcohol, de-natured alcohol. In the UK this stuff contains Pyridine dye, which is a strongly basic violet-coloured additive. Methylated spirit is very useful as a cleaning agent, since it is cheaply available in the UK. Because there is extensive water content, this material works as a combined organic and inorganic combined solvent. For this reason, methylated spirit tends to remove oily dirt rather better than anything else does. It is considered safe to use, though flammable. Has been known to wreck silk screened tuning scales, and can dissolve varnish finishes surprisingly quickly. Methylated spirit can stain metal surfaces pink or purple, and can leave corrosive salts behind when the surface has dried. For these reasons, it is often a good idea to finish with a water wash and then thorough drying. Tolerable smell, which departs after a couple of hours.

MS3: A Lithium-based automotive grease loaded with Molybdenum disulphide. Made by Castrol. Extremely suitable for use on highly loaded mechanical assemblies that slide or rotate. Safe to use, and non-flammable. Melting point >100°C.

MS4: clear silicone grease made by Midland Silicones. Excellent waterproofing and insulating properties. Not designed for extreme pressure lubrication applications, so of limited use in repairing gearboxes and dialdrives. Safe to use, and non-flammable. Has an extremely wide storage and operational temperature range. Difficult to remove, as it is strongly resistant to being dissolved by solvents. Tends to spread far beyond the point of application. Incompatible with many polishes, and can permanently smear dial plates if accidentally applied there. Needs to be kept well away from friction drive mechanisms.

Nutsert: A hard steel insert which provides a female thread in sheet metal. Fitted by a machine tool. Often found as the standard factory fit in valve radios, to secure RF covers, etc. Very inclined to fall out and get lost. Can usually be refitted with careful use of Araldite.

Paraffin: Kerosene. This commonly available petrochemical is heavier than automotive petrol, but lighter than diesel. Good organic solvent. Less hazardous than petrol, though still flammable. Can dissolve plastics. Has a mild, distinctive smell. Slightly oily, and takes ages to evaporate after use. Leaves no residue. Seems fairly well suited to removing lightly congealed grease.

Petrol: Gasoline. An excellent inorganic solvent, though very harsh. Tends to dissolve resistor colour rings, also paraffin wax as used on old capacitors. Very inclined to dissolve plastics. Highly dangerous to use, as this material is very highly flammable. Very strong and unpleasant smell which seems to hang around for days even after all traces of the liquid seems to have finally disappeared. The leaded variety tends to leave a white deposit after drying. For this reason (and for safety) it appears best to use the unleaded variety.

Rivnut: Special blind rivet fitted with an internal (female) thread. Fixed in position with a rivet compression gun. Used to provide a captive thread in sheet metal. Can be used to replace lost or damaged original nutserts.

Servisol: Specialized cleaning fluid for switches. In the UK, available as an aerosol with a long thin plastic application spout, or as bulk liquid supplied in an ordinary unpressurized metal can, intended for application by brush. Comprises a solvent, mixed with a contact lubricant which remains long after the solvent has evaporated. Often gives a long lasting, sometimes even a permanent repair for a noisy potentiometer track. Highly flammable.

Superglue: alpha-cyanoacrylate adhesive which sets so quickly that great care is needed when handling it. Useful for flexible materials such as speaker cloth. This stuff weakens in the presence of moisture but can nevertheless provide a permanent solution for indoor radio equipment. One important use of superglue is to hold parts together while waiting for a permanent Araldite solution to cure. Superglue will quickly ruin perspex, so it needs to be kept away from meter bezels and plastic dial windows.

Surgical spirit: Pure ethanol, ethyl alcohol. Highly flammable. Excellent organic solvent. Evaporates to leave no residue. Good for the most delicate jobs such as rebuilding old PCB assemblies.

18. About the Writer

Chris Parry was born in Penarth, Glamorganshire in 1953 and had decided by age 12 in Paignton, Devon to become a radio engineer. In those days he used to read Practical Wireless with faint but growing understanding, and Wireless World in complete awe. His first radio was a PSEI HU52, bought by his father as encouragement for a new hobby. Age 15 in Formby, Lancashire saw Chris enthusiastically dismantling and sometimes successfully repairing old 60° VHF TVs. After A-levels in Chester-le-Street, Co. Durham in 1972, he went to Aston University and graduated in 1976 to work for Marconi in Portsmouth, designing the receiver parts of the PV353 which was to be an entirely solid state variant of the now famous RT353 Clansman tank transceiver. Then followed many block diagram parts of the GR083, a military Band 1, 2 & 3 wideband MSK radio relay equipment.

In 1982, Chris moved to Plessey in Havant, to lead the PV5400 VHF/UHF AM & FM encrypted handheld radio team. After this, he went on to develop an early acoustic noise reduction system for the GKN Warrior AFV. Finally for Plessey, Chris worked on an adaptive HF communications system for use by the British Territorial Army in time of nuclear war. Then followed 2 years with Orbitel in Basingstoke, as chief engineer of the world's first GSM base station development programme. Next came 10 years with TÜV Product Service and BABT, working on the regulatory test & certification of various interesting radio systems including PMR, marine, GSM, 3G, Globalstar, TETRA and paging. During this period, Chris was the ETSI rapporteur for the difficult General Radio EMC Standard. In 2001, Chris joined TTPCom in Cambridge to develop 2.5G & 3G mobile phone technology. This work took him regularly to many worldwide destinations, especially Japan and China which he knows well and respects greatly. During 2006, Chris married a Chinese lady and left TTPCom to set up VCG Services Ltd, an independent telecom consultancy.

He is a dormant radio ham, licensed as G8JFJ. [Pic074] The radios in his extensive collection are rarely used. Few of the equipments depicted in this book spend more than one hour per year receiving real shortwave signals, though many spend a lot longer listening to multiple signal generators! Chris enjoys the acquisition and restoration aspects of the vintage radio hobby, but most of his pleasure comes from the technical challenge of understanding the thinking of the original design team.